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BY

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PREFACE.

THE facts observed and recorded by others assisted me to advance so far on the trodden path that I made an effort to snatch a secret from Nature.

What I succeeded in obtaining, though small, induced me to set forth in the following pages the perhaps not unimportant results.

The labour was long, and engaged my attention for years. And yet, amidst my continuous labours in the province of Embryology, it remained all the time a matter of secondary importance, my principal attention being engaged by far more extensive studies.

My desire is to stimulate others to wider observation. May the facts which I here discuss prove of utility, and encourage further studies in this direction with the assistance of modern science.

If we are not in a position to control the

processes of Nature, we can nevertheless exercise over them a more or less effective influence, so as to obtain such results as are possible.

Whatsoever the question may be that we propose to discuss, it is sometimes very difficult to reach any answer. And yet, when experience and diligence have helped us over the difficulties, we succeed at last in reaching the answer desired. The difficulties assume much less formidable shapes when an individual is satisfied with shaking his head and regarding the whole affair with mistrust. In that way the inexperienced and lazy are at once able to launch their views without further trouble. They believe, or they disbelieve; and they like to have their say. Any one can in this way easily win himself a place amongst those who have written on a topic. The man who desires to obtain a lasting place takes on his shoulders heavier responsibilities.

This book contains but a portion of the vast and wide-reaching literature dealing with the subject in hand. That literature extends back to the date of man's earliest intellectual labours. The observations that have been recorded by

others are here followed by methods of investigation, and by considerations which may serve to elucidate the facts. In conclusion, a section has been dedicated to the methods which I recommend for the artificial influencing of sex. Some particular experiments are subjoined.

May my little book, then, go out into the world and make known my views, which are founded exclusively upon facts.

THE

DETERMINATION OF SEX.

CHAPTER I.

In sexually differentiated individuals, the difference of sex is already apparent in the embryonal state of existence, not only in the exterior form, but also in the interior cellular rudiments which subsequently form the genital organs. In both the earliest forms are of such a nature that, up to a certain period, it is impossible for investigations conducted with the means at present at our disposal to discover any distinction. Soon, however, after this, in such organisms as have a distinction of sex, elementary male and female forms of the organs of reproduction can be recognised developing themselves in the embryo out of the substratum of formative elements. Some of these remain in a rudimentary condition. Others attain to complete development.

These processes take place at a relatively early

period. They do not seem to make their first appearance, as phenomena of vitality, in the course of the life-development of the cells of the ovum. But it is not improbable that, from the very outset, the ovule has a capacity to transfer (during the process of segmentation) to a corresponding cell-substance (out of which the generative organs will be subsequently developed) the force contained in the ovule, so that the cell-substance may afterwards take up the office of providing for the preservation of the species. The cells of the ovum derive this power from the protoplasma of the ovum, and retain it in a rudimentary form for one sex, whilst for the other they possess it in full measure. This energy is contained in the ovule itself in an unknown condition. In it lies the basis of the formation and development of the future sex. In close connexion with this property of the ovule, lies another faculty, included in the ovule, namely, that the other different elements proceeding from the cell-body of the ovum, starting from the protoplasma of the ovum, are endowed with certain vital peculiarities, according as they belong to the future male, or female, organisms.

It will be plain from this that the germ of the future sex must be sought in the first cell-segmentation of an ovum. As soon as some of

the cells derived from the primary protoplasm of the ovum have developed themselves into genital cells, the other elements which have originated from the same ovum are in such a manner conditioned that, in the later stages of their vitality, they adapt themselves, and, in short, adapt the properties inherent in all the cells, to the sex of the individual. According as the ovum is male or female, so are also the cells which originate from it either all male or all female.

It will be seen that not only do different cells for the different sexes develop themselves out of an ovum, but that also, at the same time with these, a peculiarity reveals itself in the other cells, in accordance with which the sexually different organisms exhibit a difference in their vital capacities, and take also different forms. The distinction between male and female characteristics appears to be determined before the fecundation of the ovum. The formation of the ova in the ovary, and their further development, seem, however, not to be independent of external influences. It is possible that upon these circumstances depend the number of ova contained in the ovary. But, apart from the question of quantity, it is possible that many characteristics might so affect the quality of the

ovum, as to exercise an influence over its capacity for fecundation. We may here mention an experiment which was made with the ova of a rabbit, from which it was quite clear that the capacity of an ovum for fecundation was immediately diminished when the surrounding elements attached to the ovule, in consequence of the density of their investing substance, offered a resistance to penetration by the spermatozoa (Schenk). The penetration of a spermatozoon into the protoplasm of the ovum becomes possible only when, in consequence of the movements of the spermatozoon the cells of the surface of the ovum can be thrust aside. This is facilitated when the investing substance is considerably relaxed, as is the case when the ovum is ripe. Other circumstances also, which can in some cases be easily detected, may prove detrimental to fecundation and development. Indeed they can even exercise an influence over the sex which is to be developed out of the ovum. Bee-masters (F. Gerstung) have frequently shown that the food exercises a striking influence upon the formation of sex in the ova (v. Berlepsch).

All evidence goes to support the view that such external influences as would favourably affect the separate sexual individual might also

promote the production of one sex or the other. In Hensen's valuable work on generation, a number of instances are adduced, gathered from various authors, which make it clear that the nutrition of the parents, apart from any question of race, is capable of exercising an influence upon the sex of the children (Ploss). In plants which produce separate male and female blossoms (Lenkhart), the male blossoms are more numerous when the temperature is relatively high, whilst in shaded places and damp soils a greater number of female individuals will be observed.

Facts which might assist to explain the origin of sex have been sought after from very early times, and have been also placed in very different lights. The result on every occasion when this subject has been discussed has been always a wide difference of opinion. People have in consequence been induced to fall back upon theories of different sorts, theories which have for varying periods, sometimes long, sometimes short, been accepted as of some assistance towards a scientific explanation. In all the theories which have been propounded, the sex has been regarded as already determined in the ovum,

or else the origin of the sex has been assigned to some early stage of the development.

The earliest statements extend back into the ages of myth and fable, in consequence of which any exact comparison of them is not an easy task. All the different manuals which deal with the present question touch upon these early views, and for this reason I am unwilling entirely to ignore them here. I shall accordingly select a few of the more important for mention.

The reproductive glands of the two sexes were supposed to contain generative matter distributed in such a way, on the right and left, that the right ovary and the right testicle contained the generative secretions for the production of males, and the left ovary and left testicle those which produced females. It is immediately evident that, according to this theory, it was impossible to exercise any influence over the sex of the future individual. This primitive theory is ever cropping up anew, always to be again rejected. Of various other theories of the same kind, only those deserve any attention which rest upon some basis of fact. Accordingly, recourse has been had to statistics, and an attempt has been made to reach, from the figures which they furnish, some certainty respecting which sex was

the more numerous, and what should be concluded to be the cause of the greater prevalence of the one sex or the other. The fact was, however, apparently overlooked that the available statistics, though in many respects of the highest scientific value, could be of real significance only when the numbers were gathered from widely distributed peoples amongst whom there was none of that wandering about the world which characterises modern society.

I am at the same time unwilling to omit data, resting upon numbers which have been gathered from statistics, and are not without value for the determination of many important questions.

Ploss has in this way shown that in favourable years, when food was cheap, the births showed an excess of girls. Under unfavourable circumstances, more male individuals were born.

A comparison of statistics, however, soon led to another theory, which culminated in this result, that in all countries an excess of male individuals were born.

To what extent this relation between the numbers of the sexes can be maintained, and may serve for a fixed rule, is at the same time a question to be regarded with caution. An unimpeach-

able result of such investigations is rendered more unlikely by the fact that comparisons of numbers lead to a conclusion of an exactly contrary nature, making the feminine sex the more numerous. These facts at once suggest that we are not dealing with fixed or normally recurring numerical proportions, which would repeat themselves at each numeration. And it is also possible that external influences may in various ways affect such numerical proportions.

We may add also that, in investigations of this kind, other circumstances should be taken into consideration. Thus, in the case of endemic or epidemic disease, the births which furnish the statistics fluctuate, and the stability of the numbers, in consequence, is modified by these exceptional occurrences.

The numbers (Oesterlen) which are based upon the population of half Europe, are amongst the widest of statistical data, and furnish information of the highest value. They represent 59,350,000 births. These showed an excess of male births. The proportions were 106·3 boys to 100 girls. Of course, these numbers refer to the new-born, and must necessarily be very much altered by the age of puberty. In fact, the powerful influences which come into play in the

life after birth would very considerably affect the former of the above numbers. This, is, however, a matter for further statistical investigation, and of little importance in our present inquiry. The numbers (Oesterlen) are in this respect very remarkable: the average of the total number of births in the various states corresponds very nearly with the numbers in the several states, or at least shows no difference worthy of consideration. In the single states, the proportion of boys to 100 girls varied from 105·2 to 107·2. Thus the proportion of the number of male individuals born to the number of females very nearly corresponded with the proportion shown by the total of all countries enumerated. Statistics derived from the genealogies of Court calendars gave (according to Kisch) 107·7 boys to 100 girls.

I am prompted here to quote also the statistical numbers given in Hensen's work, which have been taken from Darwin's *Descent of Man.* Of pigs, rabbits, and pigeons, more males are born than females. For every 100 mares, 99·4 horses are born. In the case of greyhounds, 110 dogs are born for every 100 bitches. Of horned cattle 94·4 males, of poultry 94·7 males are born for every 100 females. The degree of accuracy and the limits of error which here re-

main undefined, make fluctuations easily perceptible. The mistakes, also, which may be made in such cases, are not always the same.

Statistics have been in many other ways called in to assist in the discussion of the question before us. In the early decades of the present century a question was raised—what was the effect upon the relative number of births of male or female individuals when the parents were of like or unlike ages.

Hofacker, in the year 1828, and Sadler (an Englishman), in the year 1830, attempted to solve this problem, and found adherents for their theories based upon numerical returns. But the Frenchman, Girou (Paris, 1838), appeared as an opponent of their views, also supporting his opinions by numbers obtained in the same manner probably as those of Hofacker and Sadler.

I shall not here reproduce the tables which were constructed for the discussion of this question. Any one who occupies himself with these questions can refer to the respective technical works, and I shall content myself with mentioning some of the results. If the man is older than the woman, more boys will be born. According to Sadler the statistics showed even 121·4 boys for 100 girls.

If both the parents are of the same age, fewer boys than girls will be born. According to Sadler, in this case for every 100 girls only 94·8 boys are born. But if the woman is older than the man, an excess of girls in the family is the result. According to the two above-mentioned authors, when the mother is older than the father the proportions are—86·5 boys to 100 girls.

Similar numbers collected by other specialists differ not inconsiderably from those given by Sadler. Regarding the proportions of male and female births as affected by the respective ages of the parents, Sadler's numbers show the widest differences of all. Breslau and Noirot have arrived at numerical results so different, though less than Sadler's, that no thoroughly reliable conclusions can be based upon them. Wall confesses himself an adherent of this law, and lays down the principle that in the intercourse of two quite young parents the male sex tends to predominate. If on the contrary the age of the man is distinctly greater than that of the woman, he insists on the excess of females amongst the new-born. The French breeder Girou de Buzareingues is disposed in many respects to support the theory of the influence of difference of age in the parents upon sex of offspring; but also,

on the strength of his own experiences in breeding, is partially opposed to it. According to his theory he also takes into consideration the character, the food, &c., of the parents, and would have regard to their size and strength. In this way he gave his theory a much wider range. He mentions a great number of facts which he observed in the human subject. He outlines the expenditure of force, mental and physical, entailed on the parents by their occupation, and then sets forth ten very precise particulars from which, in any given case, the sex of the offspring which will result from the wedlock in question may be known. The following cases from Girou may be mentioned. A vigorous man married a corpulent, melancholy, elderly blonde. Seven daughters were the result of the marriage, all of them resembling their father and grandfather. Many similar cases are mentioned by Girou, all of which may be found of interest to the reader, if he be inclined to regard preponderance of temperament, or physical disposition for procreation of the species as important factors. Included in his *répertoire* of anecdotes are many interesting and piquant details respecting the results of the pairing of dissimilar temperaments which might be quoted, were it not that this would lead us too

far from our subject, and also be of no service in the present inquiry.

Bidder is in many respects inclined to give his assent to the theories of his predecessors, and states that women who bear their first child between the ages of twenty and twenty-one produce more girls than boys (Düsing). The older the woman is at the time of her first parturition the greater number of male births. An excess of male births will occur in the case of those who first give birth to children between the ages of thirty and forty (Eckhardt). Ahlfeld insists that this is a universal rule in the case of women who become pregnant in later years. A great number of specialists are of this opinion, and apply the data afforded by statistics to support it in different ways.

The evidence of Stieda, Berner, and Birelli, and especially that of Wilkens, respecting the domesticated mammals, leads, however, to this conclusion, that the theories respecting the relative proportions of male and female births set forth by Sadler and Hofacker must either be given up or their value considerably discounted.

Specialists are also to be found who, in order to explain this theory, have availed themselves

of Darwin's law, and in a certain measure the results admit of this explanation.

The older parent, who evidently under such normal circumstances as might be anticipated has a shorter time to live than the younger individual, his consort, naturally, in the struggle for life, makes an effort for the preservation of his sex. Accordingly the elderly husband of a young wife, or *vice versâ*, the elderly wife of a young husband, will make an effort to preserve the sex which is first threatened with death, but which may at least be replaced by a majority of births.

In so far as these theories are mere calculations and results which have originated from comparisons of numbers (the numbers themselves being in many cases of no practical value), the conclusions reached may appear to be astonishing, and may be used to support either one view or another, or to contradict them. Only one fact appears to be certainly established, that, on an average, under normal circumstances, the number of male individuals of our population that are born exceed the number of females. The difference amounts to a small and variable number per cent., but, in the case of the new-born, the excess is on the side of the males (Süssmilch).

Thus far we have given such data as statistics have furnished. These, it is true, belong principally to past epochs, and no new results of this sort have been used by statisticians. But it would be equally impossible to deduce from new statistics, or from old, or from both together, any law of nature affecting the question before us.

I shall proceed next to examine the further theories on this subject with which I have become acquainted from the perusal of the literature treating of it. With some of the works which I am about to mention I am acquainted at first hand. Others I know only from quotations found in various technical publications. I have not attempted to arrange my materials in any other way.

In the case of the most widely different branches of natural science, and whether the author's aim be descriptive or experimental, it is a common practice to commence with a glimpse at what has been said by the earliest writers. I shall begin in the same way. I shall, however, not take into consideration what has been at various times mere folk-lore, and is only traditionally known, but shall limit myself to such

traditions as have been preserved in writing. I have, besides, already spoken above of suppositions respecting the origin of sex which appear to partake of the nature of myths. To these it was impossible to attach any importance. And the same must be said of other views which belong to the epoch of the Greek or Latin writers on natural science, and are so strange that they can be scarcely brought into any agreement with modern knowledge.

In Ploss's work *Das Weib in der Natur und Völkerkunde* (Woman in Nature and Popular Tradition), are to be found the various speculations of different races respecting the origin of sex. Much of this folk-lore is of a distinctly surprising character, and calculated to afford the reader considerable amusement. For example, in Servia, if a man has a stye on his eye-lid he comes to the conclusion that his aunt is pregnant. If the stye is on the upper eye-lid, the child will be a male, if on the lower, a female.

Amongst the Asiatic races religious ceremonies, prayers, and similar expedients are considered efficacious, and capable of influencing the sex.

What question is there of the present day,

respecting which we can consult the literature of the ancients, that does not take us back to the writings of Hippocrates, Aristotle, or Galen, or to those of the old authors of those oriental races whom we regard as the earliest cultivated peoples? Hippocrates held that to produce a male, the generative material must be of a stronger quality. The future destiny of the male rendered it necessary that it should be constructed on a stouter foundation. He must be capable of a stronger development, and must, therefore, be a product of stronger elements alike on the father's and the mother's side. A second hypothesis was soon added to this primary one, but without any foundation of facts.

According to Aristotle, the woman supplied the primary material for the development of the future individual. It was the function of the man to give the impulse, in consequence of which the future individual came into being. Next followed the purely mythical theory, already mentioned, in which Anaxagoras believed. The much-sought-for origin of the future difference of sex in the various individuals was assigned to the right or left side of the organism. And Galen even concluded that the right side of the body was the warmer, and the left the colder,

further claiming for the warmer side the privilege of producing male individuals.

Various notions respecting the origin of sex have been also accommodated to these primitive theories of the ancients, without resting upon any positive foundation. No evidence exists to show from whom they originated, nor how they were disseminated. Nevertheless, the historical connexion of these speculations justifies a reference to them, and various hypotheses of this kind will be found in a little publication of Dr. Heinrich Janke's (Stuttgart, 1896). The older literature on the subject of the generation of the sexes has been collected by His (*Archiv für Anthropologie, Vol. IV., V.*) In *Das Weib in der Natur und Völkerkunde* (Leipzig), Ploss has collected ample information concerning both ancient and modern ideas on this subject amongst the different races of mankind. The procreative elements, furnished by the male and female organs, after their mixture, compete with each other, by virtue of their inherent forces, for the mastery. In this conflict, if the male molecules are the more numerous, a male results. On the contrary, if the female molecules are more numerous,

the result is a female. Nicholaus Venette ascribes the difference of sex to the earliest phases of the life of the ovule.

The following aspect of the origin of sex is not without interest, although the theory rests on somewhat insufficient foundations, and is applicable, in the first instance, only to those creatures which produce but a single individual at a birth. Many creatures, and especially certain species of birds, present this phenomenon; they lay in a single month two eggs. Of these, one is male, the other female. In this way a provision is made for the equal increase, in each respective month, of both sexes. In the case of man, it would, in accordance with this, be anticipated that naturally an equal number of ova of either sex would be produced by a single individual.

This would lead to the supposition that, in the case of the human female, in one month a male ovule would reach its perfect development, and in the next month, anterior to the occurrence of the menses, a female ovule. Thus the ovary of the human female would contain in one month a male ovum capable of fecundation, and in the following month a similar female ovum,

After a woman had once given birth to a child it would then be possible to form a correct idea of the distribution of the ova of the different sexes. The month of birth and the sex of the new-born child would be known, and starting from the datum that it would be the turn of the ovum of the next month to develop the opposite sex, it would be possible to fix the given month in which an individual of the male or female sex should be developed (Dupuys).

To these less general explanations of the origin of sex belong certain very startling theories dealing with the question before us. These notions are set forth at great length in theoretical explanations put in the shape of popular expositions. According to these views a single cell of the male or female reproductive glands is regarded as a sort of complicated compound structure that might be compared to a spherical world, in which thousands of primal individuals are contained, from whose powerful and secret activity results the formation of male or female individuals. (Hinz. Neusalz am Oder, 1897.)

Another very common opinion is that the seasons (Düsing), the climate, and other local

circumstances have an effect in determining the sex of the embryo. If the data supplied by Birelli, Berner, C. F. Vilson and Felkin and many other authors be taken together, it appears that the different zones of the earth's surface are not without influence in the production of one sex rather than the other. More boys appear to be born in the north, in the warmer south more girls.

Felkin and Vilson adduce the following instance from the south of Egypt:—The Wagandas, a warlike race, kill the men and the old women of their conquered foes. The children, girls, and young women they lead into captivity. On one occasion 480 of the women gave birth to children on their march. Of the new-born 79 were boys, 403 girls. This incident led the author to pay further attention to the subject on the East Coast of Africa and in the Soudan. Everywhere he found the anticipation of an excess of girls supported and confirmed. In fact his investigations of the phenomenon led him to formulate and advocate a law that the better nourished and superior parent tends to produce the opposite sex.

In this case the women are in an inferior position, and in consequence worse nourished and practically exhausted. Amongst other neigh-

bouring races, where they live peaceably and domestically, the difference between the number of new-born boys and girls is not a very great one, although a small average appears in favour of the girls. The influence of different phases of the moon has also been taken into consideration, and has been described as so effective, that some have even attempted to prognosticate by these means the sex of a second child after the birth of a first (Lioy).

From Vilson's statement, that the sex of the worse-fed parent perpetuates itself, a theory has been deduced which has been described as *cross-heredity of sex* (*Gekreuzte Geschlechtsvererbung*). In accordance with this theory a prominent phenomenon would be that the individual parents were not in a position to propagate their own sex, but were yet under certain circumstances capable of reproducing the opposite sex. If the father were the stronger a girl would result from the next impregnation ; in the opposite case a boy. A great number of authors of renown, most of whom are mentioned in works dealing with these questions, are supporters of this theory.

We have already mentioned that there are some who regard the act of generation as a conflict in consequence of which the sex of the elder parent, whether father or mother, will be reproduced, so that the sex in question may maintain its position. Similarly, in the case of the so-called cross-heredity of sex there seems to be a conflict for the preservation of the opposite sex. What conception we are to form of this conflict seems a difficult question. Any measure of the greater or less excitability of the centres during the act of generation (which might be determined in the case of animals) is not easily to be reached with any degree of probable correctness; and how much less any numerical index which would express the differences of excitability, of strength, and so forth, which might be developed during the conflict of the opposite sexes. The theory of the cross-heredity of sex rests upon the phenomenon that those female animals which are impregnated by sexually inferior and older males, whose capacity for reproduction must be considered as inferior to that of the females, produce more male than female individuals.

When a queen-bee lays male eggs, it is often asserted that these are not yet fecundated. It is

only after they have been impregnated by the male that female individuals appear. That is to say, after the male influence has had its effect, the causes which lead to the development of the female make themselves apparent, in accordance with the theory of the cross-heredity of sex. Previously this influence was wanting, and in consequence only male individuals resulted from the eggs.

From the unfructified eggs of Daphnia (water-flea) many individuals are at once developed, and in numbers so great as to be surprising. According to Heincke, female individuals can be developed from eggs which have not been fructified, but have been well nourished.

Dr. Clarke, a medical man of Detroit, is of opinion that in the commixture of the elements, which serve as the basis of the future individual, some external force is also embodied. Then the situation would be something like this: there are two elemental forms, which, in impregnation, are brought near each other, and their union actually effected; of these the female ovum has the function of occasioning a male offspring, and the male element that of occasioning a female. In this act

a conflict is supposed to take place, in which each sex strives for the production of the opposite sex. But here there would be also an expenditure of force on behalf of its own sex. This appears to be a labour of love on the part of the sexually more ardent consort, to which he or she finds himself or herself prompted by nature for the sake of the weaker female or male sex, but at the same time without any conscious volition of accomplishing an expenditure of power or energy in this (reflex) act. Richarz affirms that it is the function of the man to produce a higher degree of organization during the development in the germ. But, if the productive force of the mother is more energetic, and exerts a greater influence, the result is a boy. When, on the contrary, the generative force excited in the mother by successful fecundation is weaker, the fecundated germ does not attain the masculine sex.

Cases from married life are mentioned by different authors in which the husband, partly in consequence of sexual debility, occasioned by repeated seminal emissions on previous occasions, partly in consequence of advanced age, and besides also through spermatic secretion (*Samensecretion*), was scarcely capable of performing his conjugal duties, and nevertheless pregnancy ensued, which after

nine months resulted in the birth of a boy. In these cases the mother would have decided the sex of the child. But one is more inclined to explain the origin and development of a boy in these cases to the law of cross-heredity of sex. It may certainly be concluded from these cases that a man, from whom it might have been supposed that no procreative substance was to be had, although he can be reckoned amongst the patriarchs of his species, may yet sometimes be able to boast that he has left male offspring to be his direct heir.

On the other hand, Guttceit relates that a man, during the period anterior to his having a mistress, and whilst he was entirely at the service of his wife, begot only daughters. When, however, he limited the time which he spent with his wife by devoting a part to a mistress, his wife presented him with male offspring. This is a case which might be explained by the law of cross-heredity of sex.

Serious surgical interference with the female certainly has an effect upon fecundation. At least, pregnancy appears to be postponed after the more difficult operations. If, however, impregnation takes place, either male or female offspring may be anticipated. This contradicts the theory of

cross-heredity of sex, according to which only individuals of one sex should appear, if one ovary has been removed.

Fact which have been brought to light by experiments with animals, and by observation in the human subject, tend to give the theory of cross-heredity of sex a higher value. But, under the same circumstances, other phenomena present themselves to observation which appear to render some of the postulates of this theory untenable. Various diseases which are diagnosed by medical men as organic disorders, but which do not interfere with the power of reproduction, are apparently without influence on the sex of the offspring, and also without influence upon a striking prevalence of one or the other sex.

Richarz assigns all the power to the fecundated female individual. He thus raises the culminating point of the female power of reproduction to a height above that which other specialists will allow. In this he is in complete disagreement with Roth, to whom he is also opposed in other directions. Within certain individual limits (amongst which is not to be included a diminution of capacity in consequence of

the necessary periodical functional impulses), the female organism discharges its functions the more frequently and the more perfectly the less often it is called into operation, and, *e contra*, the less frequently and the less perfectly the more often it is called into operation. According to Vernich, very long intervals between successive pregnancies disturb the progressive increase in the weight of the children less than very short ones.

One may, without being afraid of making any great mistake, at any rate in the case of women who bear many children, make the same assertion respecting the constantly increasing probability of male offspring, as respecting the increase of weight.

The beneficial effect of a fairly long fallow season upon these periodically acting organs is revealed in this way among others, that, often enough in consequence of prolonged rest and recovery of strength, the female generative organs, after frequent still-births, became capable of producing healthy children (Richarz).

The fundamental law of crossing is supported by this author in every direction. He recommends it as revivifying the blood and tissues, in order to combat the evil effects of inbreeding, the exhaustion of normal and healthy conditions, and

as a preventative against the appearance of degeneration and decay. A similar relation between the sexes exists in their functions for the continuation of the species.

If an attempt be made (Richarz) to explain the different facts observed, in accordance with the theory in question, no insuperable contradictions will be met with. The general excess of male births, their corresponding increase during the loss of many men in war (a loss of distinctly stronger men), the high proportion of male births in the case of mothers who produce their first-born at a comparatively late age, the same high proportion where polygamy prevails, and further the diminution of male births in the case of unmarried mothers, which should not be overlooked, —all these phenomena are declared to be in accord with Richarz's views.

We will proceed here to give a brief sketch of Richarz's opinion. Ribot powerfully supports it in every particular from his own experience and from historical data. The primary impulse upon which the whole process of generation depends lies in the organs of the mother. Here lies also the substratum in which is, as it were, the centre of gravity of the special generative process.

The function of the male sex is to evoke from the feminine substratum an organism, or more strictly speaking, to occasion a change in the germ. If the mother's generative capacity reaches the highest point the result is a boy, who in external appearance resembles his mother.

If, however, it happens that the forces which act in the mother are inferior to those of the father, the infant will be a female. She will resemble her father, and will also inherit her father's temperament. Sex is not a transmissible attribute inherited directly from the parents. Personal appearance and other characteristics will on the whole correspond rather more with one of the parents than with the other. Yet in every case the influence of the other parent will make itself felt, and will in many respects exercise a modifying influence over external appearance and other characteristics.

These views have been attacked by Roth, who declares himself against Richarz's hypotheses. His objections are contained in a work entitled 'The Phenomena of Heredity' (*Ueber die Thatsachen der Vererbung*). He directly attacks the theory of cross-heredity of sex, and according to his theory claims for each

parent an equal share in the formation of the future individual, at least in the earliest stages. Fecundation, according to Roth, would at once be effective in determining the sex of the future individual.

We shall have occasion hereafter to speak of the observations which Mayerhofer has made upon the origin of sex. Here we shall mention only a single fact. This is a result of his experiments with animals, and seems to have a relation to the theory of cross-heredity of sex.

Ewes impregnated by a powerful ram bear more males than females, so long as the ram is in possession of his full forces. After a time the ram has to perform his functions repeatedly during a few days, as great numbers of the ewes are rutting. The fatigued or exhausted ram then begets only females.

Next the number of rutting ewes diminishes. The ram gradually recovers his strength. Whilst constantly employing it with the remaining rutting ewes he again begets male individuals. Now according to the rule of cross-heredity of sex, the number of females ought to be greatest at the outset, because we here have a male of exceptional force. When the ram is exhausted, according to the theory of cross sexual heredity

the males ought to be more numerous. It appears, therefore, that in this experiment of Mayerhofer's we have something which remains in want of explanation. We shall presently have occasion to speak more fully of the facts which this author communicates respecting the origin of sex in man, and will then return to this subject.

The information which we have concerning a stallion (Sir Hercules) belonging to the stud of Count Lehndorff deserves attention. This stallion was twenty-six years old, and had to cover twenty-three mares. The result was twenty-four foals of the male sex. This case of the ardent mares and the old stallion can be explained by the theory of cross-heredity of sex.

Particular attention should be here directed to a phenomenon which seems to imply that a sexually exhausted individual always has his advantage of propagating his own sex secured. It is a sort of fulfilment of duty on the part of a strong female animal when her litter shows a majority of male individuals, or male individuals only. In this connexion may be mentioned the facts communicated by Settegast, Nathusius-Hundisburg, and de la Tellais, who arrived at their results from experiments upon the pro-

portions of the sexes of the offspring of the domesticated mammalia.

Attempts to solve the problem of the origin of difference of sex by means of experiments have been numerous. So early as the last century Platz attempted to carry out experiments with living animals.

The temperaments of the breeding couple ought to be concordant. Both should be either of warm or cool temperament. Warmth and moisture are primary conditions of fertility, not in plants alone, but amongst the animals also; and (as Mayoor Zsigmond, of Kaschau, proclaimed in 1723) represent the primary conditions of the possibility of a conception.

The warm element belongs to the man: the moist to the woman. Where both qualities are to be found in both offspring may also be anticipated. But if this be not the case, for example, if the man's warmth does not accord with that of his wife, but is of a higher degree, then he can beget boys. If he be not so warm, he must, if he wishes for sons, make a distinct alteration in his diet. According to the prescription given, he ought to lead a regular life and to limit himself strictly to

warm and dry aliments. The temperament of the woman is often ardent and dry. In this state it must be regarded as unfitted for the development of an embryo. Befitting food would not be without an influence upon the alteration of temperament. Respecting this, experiments had proved this much, that a suitable change of diet can exercise a salutary influence over the temperament. A woman who was in the highest degree beautiful in face and in every part comely had a temperament which would accord with that of any man.

Then comes the theory of the allotment of the male and female in man, and in all the vertebrata, to the right and left sides of organs of generation. This is a theory which is being always brought forward, even by the most recent writers, some of whom go so far as actually to wish to support it by experiments.

Thus the excision of one or the other of the testicles of the male is recommended in order that the owner may be able to breed the sex which he desires. It still remains, in order to effect the artificial determination of the sex, that the female should also play her part correctly, so that the semen of the male may be conveyed to an ovule from the required ovary. An effort was accord-

ingly made to secure intercourse in such a manner that the semen of the male might be delivered in a certain direction in agreement with the anatomical position of the duct which was to lead the seed into the required ovary. But it was practically difficult to settle what position in the intercourse was the right one. Experience proved that in a certain case on two successive occasions male individuals were born when the impregnation had been so contrived that the semen should enter the right ovary. Therefore the left ovary was for female offspring. It is not our concern to enter into further explanations of these occurrences. Only this much may be said, that experiments have been perpetually being made which might lead to some conclusive solution of these questions without any result having been obtained.

A publication appeared in the year 1786 dealing with the above-mentioned theory, and at the time attracted much attention. It has now become difficult to procure, and is often mentioned on account of its containing much that is valuable for influencing sex both amongst men and animals that has been gathered from all the authors

of the previous century, and more especially from all the ancient authors who had written on this subject.

The author was J. Ch. Hencke, organist at Hildesheim, and the title of his book, 'The Secret of Nature completely discovered, both in the procreation of man, and for the absolute choice of the sex of children. Brunswick, 1786. (*Völlig entdecktes Geheimniss der Natur, sowohl in der Erzeugung des Menschen als auch in der willkürlichen Wahl des Geschlechts der Kinder. Braunschweig*, 1786.) The author relies upon exploded theories, according to which the offspring is evolved, as it were, out of a mixture of the generative secretions of the two sexes, and can be induced to develop into either a male or female individual. Thus the sex is not previously determined, only in the course of its development out of the developing mass, which consists of a mixture of male and female generative secretions, distinctive sexual characteristics make their appearance, according to the predominance of the male or female portion of the mixture. But here also the old theory is set forth very precisely. The generative matter of the right testicle serves to fructify ova from which males are developed, that of the left testicle is used to fructify

and develop female ova. Similarly the tenet is propounded that the right ovary contains male ova and the left such only as will, when developed, produce female offspring.

These doctrines, as a basis for the breeding of animals, Hencke had discovered by castrating swine, dogs, and rabbits. Thus it happened that a boar, who after castration had only the left testicle, twice running bred with a sow female young only. Similar phenomena occurred with other animals, so that this method was recommended by the author to the breeders of his time. But it happened also, that a surgeon upon opening the body of a woman who had had sons only and never a single daughter, found the left ovary very thin and withered, so that it was hardly possible that it could serve for the development of a new individual. On the contrary the right ovary was in a normal condition. It now remained only to discover some device for man, by which he might be able during the act of generation to avail himself of the discoveries thus made, so as to obtain the result of an absolute choice of the sex of the offspring. The ligation of one of the testicles was Hencke's infallible

remedy. When this severe proceeding proved impracticable, in its place was substituted an elevation of the testicle by means of its suspending muscle (the cremaster). Under certain conditions this takes place of itself in particular positions, and was accordingly recommended as an established proceeding for men.

One other conclusion of Hencke's deserves particular mention. He was bold enough not only to assert that the right and left sexual glands served exclusively for the generation of male and female individuals respectively, but also asserted that the generative matter from the right or left gland of one parent was productive only when united with that of the same gland of the other parent. His counsels were not for such persons as are too heated, too ardent, 'for young, hot, hasty men,' he says, 'who are altogether without consideration, I am not writing; but for chaste married people, and especially for those to whom the production of a child of one or the other sex is a matter of importance.'

Couteau established the fact that each seminal duct had its own orifice, through which the semen

was poured into the urethra. This fact was in his days of the greatest importance, as it prevented any mixture of the semen of a man's two testicles. Hencke firmly insisted that the semen was discharged by one testicle or seminal vesicle alone, in the case when the testicle was raised up. But we need not here follow further Hencke's theories which he deduced from his own experiments. In the present day these theories will satisfy no one. Results which have been obtained either after ovariotomy, or after the extirpation of testicles, have made us perfectly certain about the value of one or the other generative gland for the production of the male or female sex. The case of Schatz, which has been also pointed to as important in other specialist works, may not be uninteresting here. The left ovary of a young girl was removed, together with a portion of the left tube, and the right ovary also with the exception of a margin of about two millimetres breadth. When she was married she gave birth to a girl, whereas a boy should have been expected, seeing that only male offspring were to be produced by the right ovary.

Scarcely any work that lies before us on this subject is so much regarded as that of Hencke.

At the same time, and although it had in its day the widest circulation, it frequently met with the most unqualified condemnation. Dr. von Seligson, in his discourse before the Society of Medical Practitioners at Moscow (1895), on the subject of influencing the development of sex, in connexion with Hencke's theory, attached value to a great number of experiments tending to support the old view. It was, however, admitted that by a departure of Nature from the ordinary law (somewhat resembling a transposition of the viscera) male or female ova might occur in the respectively opposite ovaries.

De Bay, who was opposed to the theory of the anteriorly-developed sexual products of the right and left ovaries, asserts that the quality of the generative products depends upon the quantity of nitrogen existing in the chemical composition of the ovum and the semen. A large proportion of nitrogen in the ovum occasions the development of a girl. If, on the contrary, the semen contains a great quantity of nitrogen, a male individual will result. To determine the proportion of nitrogen, or to

give it scientific value in such cases, seems to be a difficult matter.

Mention is also made of cases of tubal pregnancy in which the sex was determined, and an effort has been made here also to find some support for the theory of the existence of sex in the ovum whilst in the ovary on the right or left side. Fourteen of these tubal pregnancies, described by different authors, showed boys on the right and girls on the left side (Seligson). In such anomalous cases where the embryo has developed itself in the Fallopian tube, and has not reached the uterine cavity, there is no doubt that the developed ovum originated in the ovary of the side on which it was found.

Efforts are made to confute the different objections raised in many quarters. The mention made by the traveller, Peter Kolben, of the practice of cutting out one testicle, which is the custom of certain African tribes (this is contradicted by Le Vaillant [1784], and by Fritsch [1880]), and the accounts of Otto Finsch may not deserve credit, as they rest upon assertions made by other persons. Accounts are further given, drawn from medical experience, of men

who, after prolonged orchitis, with consequent occlusion of the vas deferens, begot only children of one sex, or in other cases were unable to induce pregnancy. Also the discharge of semen was asserted not to take place from both spermatic ducts at the same time. After many digressions, Seligson in the end adheres to Hencke's theory on no sufficient grounds, and then bases on that theory a method, upon which I shall not here pass judgment, but merely mention it without describing it.

At all events there can be no question of a compression of the spermatic cord in any way, for it could not be accomplished, either manually or with the aid of various kinds of apparatus, without giving rise to excessive pain.

In this case, as Hencke in his time explained, the cremaster muscle raises the testicle up towards the inguinal canal. At complete erection the testicle is drawn up and pressed against the inguinal ring. This gives more favourable conditions for leading the semen forward from this one of the two testicles, and this portion of the semen is used for impregnation; to which end also a favourable attitude and a free passage into the ovary must be provided. According to the views of the author, this method if adopted in

procreation will lead to the desired result of producing a given sex. Exceptions are admitted. Exceptions occurred in five families with twenty-three children. The author clings firmly to his theory that each testicle possesses its own special spermatozoa and each ovary its special ova, in which a given sex is already in existence, and from which in fruitful intercourse male or female individuals originate.

Next after a number of theories which have been current on this subject, we reach some others, to which more or less value has been attributed. Morello attached weight to the concentration of the semen. Thin, liquid semen was to be favourable to the production of females: thick semen produced males. According to modern theories, based upon observation of invertebrate animals (O. Hertwig, Balfour, Landois, Minot, and others), it appears improbable that this position can be maintained. The supporters of this theory assert that a single spermatozoon suffices for the fertilisation of an ovule, or to develop the ovum into a so-called 'oosperm,' that is to say, to form a really fertilised ovum. (Perhaps the excess of semen serves for the earliest nutritive

processes of the ovum; which would, however, be difficult to prove.) This fact has been also confirmed in the case of the higher animals, and it might be in a similar manner brought to an issue in the case of man. However, observations of this kind have not yet proved possible with man. But in the case when several spermatozoa penetrate the interior of a single ovum, anomalies in the process of development result from the formation of several nuclei. Such ova also, perhaps in consequence of excess of semen, are very often aborted and perish.

In order to throw light on the causes determining sex, Pflüger (in connexion with results obtained by Born, which will be cited later) attempted to determine the relative numbers of the sexes, under normal conditions, in the case of the frog (*Rana fusca*). The numbers were taken by his pupils A. von Griesheim and Dr. W. Kochs. The identification of the sex was made with a microscope under the supervision of Pflüger. According to Pflüger the Graafian follicles are easily identified with the aid of a microscope, if they are not in their earliest stage. They contain an ovum with a scanty yolk and large germinal vesicles with germinal markings. The whole is surrounded by connective tissue.

According to Pflüger, the epithelium is wanting in such very young follicles. In these frogs after their metamorphosis the testicle consists of tubes, with multinuclear epithelia, and is easily distinguishable from the always large ovaries of the tadpoles. By different concentrations of semen, Pflüger attempted to influence the proportion between the male and female sexes.

According to Pflüger, there are normally found amongst frogs in a state of nature, 36·3 per cent. males, and 63·7 per cent. females. With thinner or thicker semen, the average number can be altered. With thin semen Pflüger obtained 27·3 males, and 72·7 females per cent. With concentrated semen he obtained 39·4 males, and 60·6 females. Pflüger carried out some other experiments, and came to the conclusion that the concentration of the semen or the extract from the testicles exercised either a very small influence or no influence at all upon the sex. When he took an average result from all his experiments, he found that out of 806 frogs which he raised, 288 were males. Whilst the normal proportion of the males developed freely under natural conditions was 36·3 per cent., that reached by experiment was 35·7 per cent. It should be here remarked that among the tad-

poles many are found whose sex is not yet determined. They are in a hermaphrodite condition, out of which they develop into either males or females.

Robin, the well-known French histologist, made the question of the origin of sex the subject of an extensive inquiry. His investigations start from the following point:—In warm climates the whole quantity of blood in the inhabitants is less than in temperate zones. The process of respiration in the inhabitants of warm climates is also not so free as in the case of those who inhabit temperate or cold zones.

From this it would seem that some process connected with nutrition, and with the passage of nourishment into the blood, is the cause of the number of male births being greater in the cold zones than it is in the temperate zones, or in the inhabited regions lying nearer to the equator. It would follow from these considerations, that if the women were subjected to such a *régime* as would materially affect their respiration and the quality of their blood more boys than girls, or the contrary, might be bred. If so, breathing an atmosphere containing more oxygen, with a corresponding diet, would be the right receipt for producing in the

woman such a basis that in the course of development the male generative organs (which Robin considers the anatomically more perfectly developed) might be evolved instead of the female. According to Robin the male sexual apparatus in comparison with that of the female is provided with the more perfectly developed character. Robin further insists that strong men will beget more male individuals. Further, that a woman who indulges in sexual intercourse somewhat seldom, has female children; and that voluptuous women, who are fruitful, generally bear boys. A number of experiments with domesticated mammalia are adduced in support of this view.

Hegar teaches that in the case of a merely rudimentary development of the germinal gland either sex is developed.

With the views of Robin may be connected also other suggestions regarding the food of the parents. These have been tried both with men and animals. But we shall not here go further into them. Nor shall we mention the different kinds of food or drink which have been employed, whether by men or women, to produce a greater sexual activity.

The eminent naturalist Born, of Breslau, made a long series of experiments, which are of the highest interest in reference to the doctrine of the origin of sex. It is easy to fertilise frogs' eggs artificially. The ripe eggs are taken directly from the female, and the testicles of the male rubbed with water. This fluid, which now contains spermatozoa, serves to fertilise the eggs. Spallenzani had already undertaken artificial fructification. Born observed, during his study of the course of development, that the effect of his breeding as regarded sex was to produce 95 per cent. of females. This number is evidently so remarkable that it ought to secure particular attention. No such extreme contrast between the numbers of males and females is to be found amongst the frogs that develop freely under natural circumstances. It seemed to Born that his result was to be referred to insufficient nourishment, and that the tadpoles, being somewhat unfavourably circumstanced, had not been able to attain the development of the stronger sex. In this experiment on the evolution of sex it appeared that not only was there an excessive production of females, but that the other organs of the embryo and its whole constitution could be modified by means of nutrition. It is also to be observed respect-

ing this most interesting experiment that many of the tadpoles perished of hunger. Now the number of still-born males of the human species very much exceeds the number of still-born girls. The mortality amongst males is so great that the average is from 136 to 140 still-born boys to 100 still-born girls. An attempt has been made (Pflüger) to explain this phenomenon in the human subject on the ground that the tenacity of life in the female sex in the period of embryonal existence exceeded that of the male. Consequently, boys would more easily perish during development than girls. If this observation made with respect to human beings were applied to the tadpoles, it might also explain the high percentage which the females showed among the frogs. Very likely the male tadpoles possessed less capacity of resistance; or, in other words, were less tenacious of life than the females. It will be understood that this view would apply only as a partial explanation of the facts set forth by Born.

In the artificial breeding of trout which is conducted under cover, in which process the embryos which have crept out of the ovarian follicle are

kept with the yolk-sacs in small reservoirs under a continuous flow of water, it is observed that single individuals develop themselves further. They lose their store of yolk with the yolk-sacs. In the course of their further development and nutrition they arrive only very slowly at the development of the internal generative organs. Even in a very advanced stage the sex is not yet so plainly indicated, as in fish of the same size living free. Indeed it is even affirmed by many persons of experience, that in the artificial breeding of trout even those that have attained their full growth remain unfruitful and cannot be used for further breeding. (D'Audeville and Arens raised in the case of trout more females by dry impregnation.)

Here might be adduced also many other doctrines of greater or less interest respecting the theory of the origin of sexual distinction. Only, in order that I may not introduce too much literary matter, I shall mention only a few of the more important and noticeable theories before I return once more to the experiments upon the influence of food upon the development of sex. Janke's work (small edition), published at Stutt-

gart in 1896, furnishes a synopsis of the literary work done, as do other books which treat of this subject.

Mons. Thury, professor at Geneva, published at Leipzic, in the year 1863, a book on the law of breeding the sexes, which, on account of its contents, attracted great attention. In this work the author, after a number of successful experiments and other investigations, shows how an influence may be exerted over the sex of plants, animals, and men.

This work stirred me up to the endeavour to devote myself to this question, so far as that might be possible. I shall give a short sketch of Thury's work, together with the critical revision of it by Dr. H. A. Pagenstecher, of Heidelberg.

The doctrine respecting the origin of sex in cattle was laid down by Thury from his own investigations. The principal point in his doctrine of the origin of sex in animals he considers to be the condition of the ovum at the time when it is fertilised. If the ovum has reached the stage of ripeness, which may be described as an advanced stage, we may expect to have, after fertilisation has taken place, a male individual, which

will develop itself out of the ovum. If, however, the ovum has reached only an imperfect state of ripeness when successful impregnation takes place, then no such powerful and perfect specimen of the race as the male is can be developed, and the result of such an ovum is always a female.

From this it follows that, according to Thury, the cause of sex lies in the ovum developing itself in the ovary, and the degree of its ripeness is the only factor in the development of one sex or the other.

It is not, however, shown what the systems are by which such an ovum can be correctly judged, so as to determine the different degrees of ripeness. We now know very well certain signs which appear upon the maturation of the ovum, of which we shall not say more here. Of these Thury could know nothing in 1863, because at that time they had not been discovered.

Thus the sex depends upon the ripeness of the female's ovum at the time of its fecundation. In the case of its having reached the highest degree of ripeness, a male is the result. It is impossible for the ovum to attain a higher degree of ripeness. If the ovum of a human female has

arrived at this supreme degree of ripeness, it has reached that stage in which it is capable of becoming the basis of the most perfect living creature which exists upon our globe.

Rutting is an external sign of the maturity of the ovum amongst the lower animals. When, during the rutting period, an ovum is detached from the ovary, and passes through the Fallopian tubes to the cavity of the uterus, the fructification can take place at the beginning of the rutting period. At this period its ripeness is not so far advanced. The result of the development of such an ovum is a female. But when the fecundation has taken place at the end of the rutting period, the ovum has reached its highest degree of development, and, if effectively fecundated, it will become a male. It follows that the signs of rutting should be carefully studied, as in fact is habitually done by practical farmers. The duration of the rutting period and the influences which affect fertilisation should be accurately known in order to lead to any practical result.

Females, at their first conception, would usually produce, or would be particularly disposed to produce, female individuals. Experiments succeed better with such as have often produced young. In their case the symptoms

which indicate the commencement or the conclusion of the rutting are much more easily determined, so that they are better adapted for these experiments.

We know well that in the case of the lower animals when rutting, as in the case of the human female during menstruation, an ovum is liberated from the follicle in the ovary, and ordinarily passes away in the menstrual discharge. In fact, a follicle of the ovary bursts, and, to be precise, that one which protrudes most beyond the surface of the ovary. This bursting of the follicle has not actually been observed. But that this event takes place there can be no doubt, for the locality of the fissure is perceptible, and the ovum is found either at hand on the ovary, or else on the fimbria. The increase of fluid in the follicle of the ovary, and the excessive charge of blood in the vessels on the walls of the follicle, seem to be, without any actual contraction taking place, the physiological causes of the freeing of the ovum from the follicle, so that it may come in contact with the semen. Ovulation can take place without intercourse. But sexual intercourse can also favour ovulation; at least, it appears to

facilitate the separation of the ovum from the ovary.

Bischoff made known the fact of the separation of the ovum from the follicle. He showed that the presence of sperm in the feminine organs of generation of the animals was indifferent, that the rutting of the animal was the index of the ripeness of the ovum. Eimer, Beneke, Van Bamecke, and Hensen call attention to the phenomenon which is observed in the case of bats, who for a whole month before the detachment of the ovum from the follicle have their uteri full of semen.

These processes which take place at rutting time are attended with sexual excitement and congestion of the external genitals. It is not, however, necessary that these processes should in the case of all animals occur at the same time as ovulation. If rutting animals are restrained from sexual intercourse, the sexual excitement of the female passes off; but the symptoms of rutting again make their appearance after a time. These are the phenomena of the so-called rutting season.

This rutting season lasts with sheep fourteen days, with swine fifteen to eighteen days; with

cows, horses and apes four weeks. It corresponds to the menstruation of the human female (Hensen). Many bitches admit the dog only when six or seven days have elapsed since the issue of blood. In the case of many animals rutting is marked by a flow of blood from the genitals. This is the case with apes, bitches, swine, and many other mammalia.

Under these circumstances, the symptoms of rutting are sufficiently distinctly marked to make it possible, as Thury suggests, to determine the advanced state of ripeness or its commencement in the ova. But it is scarcely possible to say when the period of ripeness commenced in this ovum or that. An ovum which had begun to ripen early may, at the beginning of the rutting time, have attained to the condition of a male-producing ovum. At the same time, others which are fertilised at the conclusion of the rutting, but had begun to ripen comparatively late, may, at the end of the rutting time, not yet have advanced far enough to be able to develop male individuals.

Thury bases his doctrine on a number of phenomena of the vegetable and animal world,

and upon various experiences in the case of man. He also adduces many statistical data in explanation and support of his theory.

The observations on plants make it indisputably clear that all the circumstances which favour growth and ripening are favourable conditions for the development of male organs. If all these circumstances are lacking, female organs are produced.

Dark and cold, for instance, cause the male organs to perish. In recent times a great number of extended studies of the phenomena of vegetable life in this direction have appeared. I may mention more particularly the following experiments made by M. von Treskow in Gorlitz with *Arisæma* (Verhandlungen des Botanischen Vereins der Provinz Brandenburg, 1895). This plant first produces male flowers. In the later year, when it has become larger, it produces female flowers. The transition from the male flowers of the early stage to the female flowers of the later stage can be hastened at pleasure by planting in rich garden mould and manuring with horn shavings. If, on the other hand, the plant be placed in poor, sandy soil, it reverts to the male flowers. The same author quotes in his essay a remark of Heyer's (Halle, 1884), who declares that no sufficient

observations exist respecting the influence which different situations exert over sex.

I adduce this instance, for the sake of remarking respecting it, that on this subject also controversies exist, which must be settled by wider studies of the life of plants.

Cornaz has tried to derive from cows evidence in support of Thury's theory. He had twenty-nine cows impregnated with attention to the rutting time, and from twenty-nine births received twenty-two females and seven males. Cornaz attested his experiment by a declaration, and the experiment was repeated in the French state domains.

But the experiment alone was striking enough to invite repetition. It also met with partial success. But the plan was afterwards entirely given up, perhaps in consequence of disappointments.

In this case it very likely happened—as in such experiments it very easily may happen—that, in consequence of insufficient practical knowledge on the part of the experimenter, the actual commencement of the rutting time was overlooked. In addition, it is well known that animals, in consequence even of an amount of exercise not very exhausting, and in many other ways, as well

as in consequence of the food they have taken, may exhibit variations in the activity of their rutting. It is not, therefore, surprising if the results of experiments show much that was unexpected.

I here pass over a great number of proofs which Thury gives in his essay. Funcke (1866) made in his *Physiology* the following remarks on Thury's theory:—'Although the origin and determination of sex is not indisputably proved to depend upon the degree of ripeness of the ovum, it appears to me that we have not reached the right time for determining the factor upon which it does depend. These experiments have been made to repose upon a fact, which fact certainly proves, beyond the possibility of dispute, a relation between the fertilisation of the ovum and the subsequent sex. This fact is that, in the case of certain creatures capable of parthenogenesis (unisexual procreation), we find that, from unfertilised ova one sex always results, and from fertilised ova the other. But any closer interpretation of this function of the semen is rendered nugatory in advance by this, that it is in some cases the male and in others the female that results from the unfertilised ova.'

Thury's theory can be very suitably brought into agreement with the theory of cross-heredity of sex, and explained by the assistance of that view. The cow, at the beginning of her rutting, is not in a condition of great sexual vigour. If the ovum be effectually fertilised, it may be supposed that the bull, in procreative activity the superior consort, will be fitted not to reproduce his own sex, but that of the weaker cow. At the end of the rutting period the cow, which is brought to the bull, has her ovum ripened to the highest possible degree, and in consequence, when compared, from a sexual point of view, with the bull, is distinctly the stronger and superior, and a male calf is in this case the result of conception.

According to the theory of cross-heredity of sex, female creatures should in the former instance be produced, and in the latter males, which same result is reached in accordance with the theory of Thury.

Attempts have been also made to apply Thury's theory to the human species. The menstruation of women has been compared with the rutting of the lower animals, and has been considered a protracted, oft-repeated rutting. Now, as an ovum is specially developed every month,

it follows that this ovum requires a certain part of a month to attain a more or less advanced degree of ripeness. According to this, the ova which are fertilised a short time after menstruation, will develop only female individuals, whilst those which have had a longer time in which to attain to ripeness would develop themselves into males.

The mucous membrane of the womb ought, about ten days before the beginning of menstruation to thicken itself distinctly in consequence of a turgescence and dilatation of the vessels. In consequence it appears swollen and loosened, and it has reached the culminating point of swelling when the menstruation is at its highest. After menstruation the swelling does not immediately decrease, but lasts on for about nine days, until the mucous membrane returns to its normal condition (Hensen). Thus it seems that the swelling and hyperæmia in the womb appear at the same time as the conditions which lead to the ripening of the ovum. The fertilisation of the human ovum would be therefore most efficacious at the time when the mucous membrane of the womb is also most appropriately prepared, and it is probable that the same moment is the one when all the other coin-

cident factors are of a sort best calculated for the reception, the fixing, and the protection of the ovum. It is simultaneously with these processes in the mucous membrame of the womb, and in the other parts of the generative organs of the woman, that the ripening of the ovum is effected.

Now, it may appear not to be a matter of indifference (and may very likely even have some connexion with the development of sex) whether the ovum is fertilised at a period during which the mucous membrane is passing through its changes in order to reach its highest point of swelling, or at the time, when, after menstruation, the mucous membrane is, during so considerable a period (nine days), passing through a retrograde metamorphosis in order to return to its normal condition. This protracted process seems to correspond to the protracted rutting in the form of a menstruation. If so, the human uterus, as Thury's theory would declare, would be prepared, to a certain extent, in different ways for the reception of the ovum according to the different sex-conditions of the future child.

It is not sufficiently known to how great an extent the principles of Thury's theory have

hitherto found their right application to the case of man. They seem in practice to be applied in different ways.

It seems that in cases where a result was obtained it could be more easily explained by the principles which have been already described under the theory of cross-heredity of sex. The assumption of a greater or lesser degree of ripeness of the ovum which was to be developed was a very questionable one.

The different processes with which we have become, in more recent times, acquainted as symptoms of the ripening of the ovum are not here intended. Such symptoms can be observed both in the ova of the invertebrata and in those of the vertebrata. These symptoms, which are such as the attainment of the normal size of the ovum of the species in question, the protrusion of the orientation points (*Richtungskörperchen*), the steps towards the formation of a female anterior nucleus (*Vorkern*), &c., do not here apply, for the recognition of that higher degree of ripeness in the ovum which is necessary at the time of fructification for the development of a male individual.

All the above symptoms occur alike in the ova destined for the male and for the female sex.

That ripeness of the ovum upon which Thury's theory insists, lies in the nature of the ovum apart from any anatomical signs. It is a condition of the ovum which we can only attempt to explain by laying down the principle that an ovum which has been for a longer time prepared in the female generative organs previously to its fertilisation, must be riper than another which has had less time for this preliminary process.

We have mentioned above that on the occasion of Thury's experiment, the desired result was effected in twenty-nine cases. Pagenstecher, Siebold, and Köll have dealt critically with Thury's work. Coste was not in a position to confirm these experiments, nor to verify them. In order to test Thury's results as applied to the human subject, Schröder obtained the assistance of young women, who were in a position to give him positive and accurate information respecting the time at which they became pregnant. The women could name the day on which they had had sexual intercourse, and knew the date of the last menses. From careful calculation of the interval between these dates, it was possible to ascertain approximately at what stage impreg-

nation of the ova took place ; the degree of ripeness of the impregnated ova could also be inferred from the space of time that had elapsed since the last menstruation, and the sex of the fœtus was noted. Schröder found that on an average of twenty-six cases, in which boys were born, the conception had taken place 10·08 days after menstruation ; on an average of twenty-nine cases in which girls were born, 9·76 days after. In consequence, he was not able to confirm Thury's theory in the case of the human subject.

The experiments of Albini in Naples (according to Kronecker's report, *Centralblatt für medicinische Wissenschaft*, 1868), which he made during four years in his great poultry-yard, showed in the first place that hens for eight days after being separated from the cock laid none but fertile eggs. On the ninth and tenth day the fertile and infertile eggs were of equal number. On the twelfth day all the eggs were infertile. Nevertheless fertile eggs appeared even on the eighteenth day. It is possible that they had been impregnated by spermatozoa which had remained in the folds of the mucous membrane of the uterus.

Hens never yet impregnated, or such as had not been impregnated for at least a month, in three days (? after impregnation) laid fertile eggs, which increased in number daily.

According to Albini, hens can in Naples leave the eggs which they are hatching. The shell can be partly broken off and again replaced without the embryos necessarily perishing. But care must be taken that no fungoid growth reaches the germ, as this is easily fatal to it. Indeed, it has been recently shown that new-laid or well-preserved eggs are free from all micro-organisms. When these appear they have made their way into the egg through the mechanically injured or otherwise altered calcareous shell. They do not have their origin in the egg from the mother. The egg of the bird is perfectly free from micro-organisms when it is laid. If, however, only traces of pure cultivations of micro-organisms be in a suitable way applied to such eggs externally (Lenderer), they always have a fatal effect upon the developing germ, even when they are not any of the so-called pathogenic microbes.

And now the result of Albini's breeding experiments upon poultry with respect to the origin of sex.

From three to six days after intercourse with the cock the hens lay eggs, from which on the average an equal number of males and females are developed. In the warmer part of the year the number of males appears to be greater.

Better nourishment of the parents seems also to exercise an influence over the sex of the young.

Such eggs as were laid from ten to fifteen days after complete separation from the cock, gave when hatched generally a distinctly greater number of females. Albini found that the greater number of these died of anæmia. He ascribed that to imperfect fertilisation, and considered that development of an excessive number of females was to be ascribed to the same cause.

Albini inclines towards the theory of Thury, in accordance with which the principal cause of the development of sex lies in the degree of ripeness of the ovum. He is opposed to the theory of Coste and Gerbe, which declares that the ova of the birds and mammals are fertilised when they fall from the ovary. The place where this took place was, according to their theory, exactly localised, at the opening of the Fallopian tube, and not at any place in the length of the tube.

Fertilisation in the Fallopian tube or uterus is allowed to be possible, and it is admitted that, in

exceptional cases, fertilisation of the hen's egg is possible so long as it is not surrounded by the shell-membrane.

This opinion, however, is in direct contradiction to that of Lenkart and Newport and many others, who hold that the albumen, which gathers around the yolk in the oviduct, hinders the penetration of the spermatozoa into the yolk. When Albini had collected his facts he came to the conclusion that, in the case of animals which bear many young, the last are mostly male, and explains this by the hypothesis that the ova passing through the Fallopian tube thrust the semen back, so that the ova which come behind are therefore fertilised in a more advanced stage.

Meyer believes that he has incontestably proved against Ahlfeld that the sex is determined at conception. He does not appear to be disposed to admit the existence of male and female ova in the ovary; but he thinks it absolutely certain that the sex is determined at conception by the reciprocal action of the ovum and the semen. This view follows from the fact that, as Thury's theory demands, a fertilisation and a determination of the sex must necessarily take place as

regards time either at the beginning or the end of the mingling of semen and ovum.

The longer the ovum exists free from the ovary, the longer it remains without the surrounding of those elements (contained in the ovary) which are necessary to it. Apparently, in consequence of the absence of these elements, it is all the time drawing nearer extinction, or it may at least become gradually less capable of maintaining its own sex—which is feminine. At least, it appears, before it is overtaken by the total extinction which threatens it if it is not fertilised, to lose the energy necessary, when fertilisation ensues, to maintain its sex, and so may become fitted to assume the opposite masculine sex. This much, however, seems to be quite certain, according to Mayerhofer, that the human ovary does not contain male and female ova already possessed of sex. Equally impossible is it to imagine male and female seminal filaments (spermatozoa) already existing in the organism, and provided with distinct capacities for generating definite sexes. We are unacquainted with any special anatomical signs indicating any such distinction, and do not, even after microscopic investigation, find ourselves prompted to assume the existence of such dis-

tinct forms as would allow us to conclude the existence of so fundamental a difference. It is true that in many of the lower animals different forms of spermatozoa are known. These are developed in one and the same testicle, and under the microscope whisk about confusedly with vivacious movements. We find this in the case of a kind of snail (*Murex brandaris*). If we observe a drop of the semen of this creature diluted with sea water, the greater number of the spermatozoa, possessing head, central portion, and tail, move about very energetically. Amongst them are other spermatozoa, distinctly larger and of different form, whose shape suggests spindle-like elements, ending in thin thread-like tails. All these objects exhibit a striking vivacity of movement. Whether these objects represent a particular kind of spermatozoa (as some have supposed), exhibiting definite sexual character, or whether they are not cells, striking on account of their movements, out of which spermatozoa are developed (the so-called spermatides or spermatogonia, transition forms out of which spermatozoa are developed), is at present an open question.

H. A. Pagenstecher attempted an important readjustment of Thury's theory, and tried to

show that it might be made concordant with what had been elucidated by previous observations. He holds fast to the axiom (Joh. Muller, Home, Geoffrey St. Hilaire, &c.), that the embryo is at first sexless, and that the ovum after its fertilisation still has this character, and must possess the potentiality of developing its sex in two different directions. The factors which determine sex must be external to the embryo.

Pagenstecher remarks that the relations which have existed anterior to the fertilisation of the ovum, as well as its age (with which its ripeness is connected), are from the outset without influence on sex.

The embryonal germ, before its fertilisation, is an embryo whose sexual development is undetermined. In this case fertilisation acts as an external factor in the direction of determining the sexual quality of this indeterminate embryo.

The act of fertilisation would be of influence upon the sex of the embryo in accordance with the character of the father. That follows from Pagenstecher's explanations of Hofacker's observations. According to Hofacker we get from men of twenty-four years of age and upwards, as also from sheep of a certain age, an

average of a greater number of males. In the case of mothers also, as we have already pointed out, the sexually-stronger age (Lenkart, Girou de Bouzareingues, Hofacker, Morel de Vindé, Sadler) and the food have an influence upon the majority of births of female individuals. Here should be added the experience of Nasse and Van den Bosch. The observations of Dzierzon, von Siebold, Lenkart, and von Berlepsh, on the development of sex in bees, and, according to von Siebold, among the Psychids, should also be taken into consideration. When the females of certain Psychids are not impregnated they lay only female ova. If they are impregnated, male ova appear also. The tree-lice (Cestoni, Réaumur) give birth to living young without impregnation. These are at first only female, *afterwards males appear as well.* After this impregnation commences, and the females begin to lay ova.

The experiments of Knight, who found that melons and cucumbers produce male blossoms under higher temperature and female under lower (which was verified by Mauz), demonstrate that, in this case, such external factors as warmth, light, dryness, have an influence upon sex. Pagenstecher, however, believes that the con-

ditions of origin of sex are not the same in animals and plants. We must not, he says, from these observations draw conclusions off-hand respecting the sexual propagation of plants nor of animals in general.

It must be further pointed out with regard to the thesis that ova which are emitted last have had more time to ripen, that we must reflect whether the process of ripening may not have also begun late.

Thury's observation that the last egg laid by a singing bird developed a male (communicated by O. Bourrit), and that in the case of hens the majority of the later eggs were males, seemed to Pagenstecher not quite certain. He mentions also a method by which, in poultry breeding, the breeding experiments can be conducted on a regular principle, which I shall quote word for word.

'For this experiment a number of hens are taken which may be anticipated to be sitters, unless the use of incubators is preferred. The hens are to be separated, and the eggs which each one lays in her own particular nest are to be marked with numbers corresponding to the days on which they were laid.

'The eggs of the different hens are now to be rearranged, so that the eggs which each particular hen is given to hatch shall, as nearly as possible, have the same numbers. For example, if the number of the hens be six, and the period of laying up to the time when the hens begin to sit be thirty days, one hen will have eggs to hatch with the numbers 1 to 5, the next 6 to 10, the third 11 to 15, the fourth 16 to 20, the fifth 21 to 25, the sixth 26 to 30.

'In this way the doubt will be avoided, which necessarily arises, if I give the eggs of one hen, although marked, to be hatched by her alone.

'In the latter case, it can very seldom be known with certainty from which egg-shell a cock or hen issued.

'In this experiment, on the contrary, one can quietly wait until the cocks and hens in the growing broods of the different hens can be clearly distinguished and numbered, seeing that each brood has numbers (of the days of laying) of very nearly the same value. The experiment is easier and less subject to the possibility of error when the eggs belong to different varieties and are taken from known parents.'

Fertilisation in many cases alters the future sex as soon as it affects the germ in some corresponding manner. The germ develops itself, and, in the case of creatures whose ova develop without fertilisation, evolves one, or the other, or both of the sexes. According to Pagenstecher, fertilisation often alters the determination of the sex of the germs which attain to development in the ova. The point of time in the life of an ovum, at which it has reached that degree of ripeness which gives it such a character that the semen can no longer effect the determination of the sex, cannot be absolutely settled. A more powerful bull might beget female calves earlier in the late rutting time than an older one.

After further explanations and critical expositions, which suggest themselves in the course of the examination of the theory, Pagenstecher lays stress upon the following important dicta of Thury's teaching:—

1. Sex depends upon the ripeness of the ovum at the time of fertilisation.

2. The ovum which, at the moment of fertilisation, has not yet reached a certain degree of ripeness, produces a female. If this degree of ripeness has been passed, the ovum upon fertilisation, produces a male.

3. If at the time of rutting a single ovum is detached from the ovary, and descends slowly through the genital canal (animals which bear a single offspring), fertilisation taking place at the beginning of the rutting suffices to produce a female, and at the end of the rutting to produce a male, provided that the change in the condition of the ovum takes place normally during its passage through the genital canal.

Both the theory as Thury stated it, and the critical remarks that have been made upon it, have been further elucidated in many subsequent works. Here Pictet, Chavannes, C. Vogt, De Philippi, and others have taken part. Pictet believes in the uniformity of the sexual life of vegetables and animals, so that both would be subject to identical fundamental laws.

The facts, which stand in certain relations with the fundamental laws, are numerous, and the manner in which they tend to affect those fundamental laws, occasions various combinations in the variety of phenomena.

For the animal kingdom Thury adduces a number of observations as the foundation of his teaching. We shall here turn our attention to some of them.

We have already pointed out that in the case

of the eggs of the singing birds, which are laid by turns, the young which emerges from the last strikingly smaller egg, the so-called 'nest egg,' is always a male.

According to the theory of Thury, the ripeness of the ovum depends also upon the place which, in the animals, it occupies in the ovary. In consequence, according to this author, it is not improbable that we shall find an irregularity in the successive production of male and female ova.

If the activity of the generative apparatus of the female should be increased by any circumstance, in the case of the animals the ripening of the ovum would be accelerated. The consequence would be an earlier detachment, or emptying out of the ova from the ovary. In consequence, the generative operations in the animal are of a more complex nature than in plants, a fact which is of great significance for the determination of sex.

The continuous intercourse of the male with the female increases the capacity for accelerating the ripening of the ovum. According to Burdach the mother animals who do not have frequent intercourse with the male bear more females, because their ova do not, before fertilisation, attain so high a degree of ripeness as to be able

to develop into males. Also it appears, from observations on animals, not to be improbable that the male chooses the time of intercourse. The determination of the chosen time depends upon many influences. The causes of choice may be sought in many factors. Some of these depend upon external influences; others have internal causes. The causes may be general or personal. They may depend upon external form, or be occasioned by other phenomena of the animal world. It is always easy for these phenomena, which in their nature are of the most different kinds, to escape observation.

Amongst cattle and sheep the first-born are more often females (Girou). Also in the human species a greater number of females are observed amongst the first-born. Here, on the one hand, regular intercourse with the male is to some extent unfamiliar; whilst also, according to Thury, the choice of the date of marriage might be of importance. The constancy of the births may be explained by the regularity of the intercourse of the two parents in consequence of the reciprocal ties which surround family life.

From illegitimate births more girls result than from marriage. The reason of this might be sought in the influence of the active excitement

of the female at the time at which the conception took place, that is, shortly after menstruation, when the woman is most easily excitable.

The various theories respecting the explanation of the production of sex which are known to us, from the earliest accounts down to the modern predominance of natural philosophy, have been collected by W. His (*Archiv für Anthropologie*, Band 4, 5).

Since then, it is true, during the course of successive studies, and more especially of those which have been made during the present century, many substantial alterations have appeared in the views held respecting the cause of the different development of sex. We have seen this above.

Thus discoveries have been made which have exercised a very wide influence, for example, that of the ovum in man and in the other mammalia (Baer. 1828), or the penetration of the spermatozoa into the protoplasm of the ovum as a necessary condition of fertilisation. In later times it has been made certain that the head of the spermatozoon is a nucleus, and that only one spermatozoon penetrates into the interior of the

ovum. Afterwards its head as a nucleus unites with a nucleus part of the ovum, forming a new nucleus in the ovule, which, together with the surrounding protoplasm, serves as the point of departure of the further processes of development, and in this condition is described as an oosperm. After this follow other extensive details of the process of development, which will not be described here. It may be already seen, from the few principal factors of the process mentioned, that our theory respecting the development of the sex in the embryo will have to be substantially altered. We shall here adduce only the fundamental doctrines respecting the development of the generative organs laid down by Waldeyer in his masterly work on the ovary and the ovum. The teaching for which we are indebted to His, Kölliker, Schäfer-Korschelt, Heider, Duval, Kollmann, Minot, Bonnet, Bergh, Prénant, Balfour, Romiti, Kuppfer, and others, must also be well remembered; as well as the acquisitions of new information connected with the physiology of the embryo, and, of quite recent date, the mechanism of development (Roux), which can acquaint us more especially with the particulars respecting the states and processes in the ovule during the earliest life-stages of its development.

The doctrines of the physiology of metabolism in men and beasts under different circumstances have exercised so powerful an influence over our comprehension of the relations of the individual during the sexual-life, that we practically find in all these teachings a powerful support, whence we may obtain many elucidations bearing upon the question lying before us, and may discover the principles necessary to complete our theory.

But, before entering upon the fundamental principles of the theory, which I have set forth, I wish to mention a treatise of Mayrhofer's, the principal results of which I shall briefly recapitulate. After that I shall mention briefly such information as I have met with respecting the nutrition of the mother.

Mayrhofer was led by critical notices and the observations of others, and further by his own experiences, to conclusions which he set forth in propositions some of which I select here.

In the plants and the lower animals food plays a principal part in the development of sex. The sex is not generated, but depends upon external influences over the fruit which is in a state of development. And here we have a stage which precedes the separate sex in man, in which

stage sexual neutrality must be regarded as normal, where also we find a kind of hermaphroditism.

Whether sex in the human species is determined at conception, or only develops itself afterwards, we must attempt to discover from obstetric experience.

The twins and triplets contained by one chorion are of the same sex and have a common placenta, in which the blood passages of both umbilical cords communicate with one another. On this account also many opine that the identity of sex is occasioned by the intermixture of the blood, an opinion regarded, on the contrary, by others with incredulity, because the intermixture of the blood might very possibly lead merely to a mixture and not to homogeneity, under which circumstances dissimilarity of development would be possible enough. We may here adduce the following facts also (Jhering): The armadilloes produce a number of young in one litter, which are normally developed in a single chorion, and are of the same sex, as is the case with man when twins are developed in one chorion.

Heartless monstrosities (*Acardiaci*) are, in spite of imperfect nutrition (the conditions of proper nutrition by the blood are wanting in the

embryo), of the same sex as normal offspring. Now cases of this kind demonstrate that, in the later periods of development, although the conditions of nutrition are not alike, nevertheless the similarity of sex in the twins is maintained; so the foundation of the future sex would be laid at the period of conception. This rule which proves valid for the twins found in a single chorion, would apply for all human ova in general, because all possess the capacity of attaining their sexual character at conception.

According to Mayrhofer, placentæ are rare in which, where there are two chorions, communication is found between the vessels of the two umbilical cords. In addition to what has been already mentioned, Mayrhofer lays down the law, which we find frequently stated in many quarters, that the older of the two parents has a greater preponderance in favour of the propagation of his, or her, sex. Especially the physical maturity on the man's side enables him to propagate his own sex, either in connexion with younger or older women. A superiority on the part of the woman produces girls.

Our author only partly supports Thury's theory, and considers it an open question whether the time of impregnation has any influence on the

origin of sex. But he lays down this principle, that an economy of the semen by infrequent indulgence in intercourse is extremely favourable to the production of males.

It may be possible to obtain more exact data respecting the origin of sex from the artificial breeding of fish. In this case the properties of the sperm, as well as of the ova, might be observed at an earlier date by means of a fertilisation effected externally. Attention might be also paid to the age of the parents. In short, all the factors of artificial influence upon the development of sex can in this case be taken in hand and controlled by varying the process of artificial fertilisation. The author does not appear to know that the results obtained by artificial breeding differ remarkably from those which are the consequence of the natural multiplication of fish, nor that the development of sex is unfavourably affected in many ways. The cause of that lies very likely in the nutrition of the young fry, and perhaps also partly in cross-breeding.

What influence the physical welfare of the parents, and especially of the mother, has on the sex of the offspring in man, besides other factors deserving of attention, ought to be discoverable

from the statistics of the lying-in hospitals. This is, in my opinion, hardly to be expected.

On various occasions, whilst taking into consideration the possibility of an influence on the part of the parents over the sex of the child (in such respects as have been placed before us in the literature dealing with this subject), we often had occasion to direct attention to the food of the parents. And especially the food of the mother seemed to us to be of the highest importance.

Now, it is universally known that metabolism is increased during pregnancy. The products of excretion in the case of pregnant women are much smaller than the quantity of matter taken in, in the shape of food. The difference, to a great extent, represents the matter taken to form the bodily substance of the embryo, in accordance with the anterior laws which have been fixed by the doctrines of the physiology of metabolism. It will, then, be necessary to pay particular attention to the investigation of metabolism. Suggestions are not wanting. They will be found amongst the observations of leading specialists. For example, Winckel observed that during pregnancy the

temperature was slightly raised. This increase of temperature must practically be explained as due to the higher and more productive process of oxidisation, which has to be accomplished by the human female for the sake of nourishing the fœtus.

During pregnancy the number of blood corpuscles suffers an observable diminution. Still plainer is the reduction of the quantity of hæmoglobin, when measured with Fleischl's hæmatometer. This last phenomenon is very likely connected with a greater consumption of hæmoglobin, the substance being used up by oxidisation.

Observations of sitting hens are not without interest. In their case also a diminution of hæmoglobin is observable during the period of incubation. The hæmoglobin can sink to nearly 50 per cent. of the normal amount. With the increase of hæmoglobin in the embryo and its simultaneous diminution in the mother during incubation, it happens, at a certain period in the process of development, that the embryo in the egg and the sitting hen possess a nearly equal measure of hæmoglobin with a nearly equal number of blood corpuscles. An increase of the quantity of hæmoglobin until the normal amount is reached may be observed in both towards the end of incubation.

The Rhine salmon each year go up in a well-nourished condition from the sea into the fresh-water streams to spawn. There they remain several months. They lose much of their muscular substance (Miescher). On the other hand, a great development of the sexual organs and of sexual secretions takes place, produced probably at the expense of the used-up muscular substance.

Many have paid particular attention to the nourishment of the maternal organism. Investigations have also been published dealing with the nutrition of the parent animals in cases when it was desired to exercise an influence over the sex.

In fact, we have frequently touched upon such subjects, although only lightly. Here, as we are about to proceed to the subjects of nutrition, and metabolism in the human female awaiting impregnation, we find ourselves compelled to acquaint the reader with a number of facts which permit us to assume a connexion between the food supply (including metabolism) and the development of sex.

CHAPTER II.

ACCORDING to St. Hilaire, the male sex is more common in the case of scantily nourished (and therefore weakly) animals. Girou de Buzareingues says that the same is sometimes the case with domesticated mammalia. Martegoute has found that the sheep which bear female offspring are, on the average, of a heavier weight. Furriers have remarked that in fruitful regions more furs of female animals are always to be had than in unfruitful districts. It would follow from this that better nourishment assists the production of females.

This observation seems, however, to be concordant with the general practice of farmers, according to which it is usual to keep a greater number of the females of the domesticated animals, on account of their utility. The males are kept only in such numbers as may be absolutely necessary for breeding purposes, or for stronger beasts of burden. The surplus is, by means of trade, disposed of in other regions. In consequence, in poor unfruitful districts, the

number of males is pretty nearly the same as in fruitful regions, the actual requisite number being in both cases about the same. The females, on the contrary, can be much better kept in fruitful districts, where there are rich and fertile meadows and better fodder, than in the poor regions. In the latter the females are consequently rarer.

Wilkens attempted to apply diet to the production of sex in the domesticated mammalia, and laid down the following principles: The food must be of influence upon the embryo in the mother's womb, and the better nourishment favours the female, the worse the male sex.

We have already mentioned the views of Robin and Born respecting the influence of food.

Düsing turned his attention to the effect of diet upon horses with a view to the development of sex.

The state of nutrition of the parents would have an influence upon the development of the embryo. In this case also the better condition produced females, the worse males.

According to Düsing, if the mother was well nourished, old semen operating upon a young ovum would produce a majority of female offspring. On the other hand, if the mother was

insufficiently fed, young semen operating upon an old ovum would produce a majority of male individuals.

According to Wappaens, richer or poorer nourishment in years of different fruitfulness in Sweden has no effect upon the prevalence of one or other sex.

Ploss also tried to draw attention to the fact that better food, in the case of the male as well as of the female parent, could have some effect. Thus a balance of the numbers of the two sexes depended upon the better or worse harvests in different regions. If an excess of one sex appeared in one year, in consequence of an abundance of food, in the next year unfavourable circumstances raised the number of the other sex, and thus a proportion was reached which represented the normal numbers.

According to Fiquet, female calves are born if the cow is poorly fed. This diet should last some weeks, but the bull should be abundantly fed before serving.

According to Landois, food plays a most important part in the determination of sex amongst insects. If the germ be richly nourished, females are principally developed (Landois, *Physiologie*).

A great number of different foods and drinks,

and also substances which have direct medical effects, are commonly known or held to exercise an effect upon the activity of the generative organs, and of these some are also recommended under medical advice.

Many of the medicinal substances should be carefully avoided. The use of them may prove deleterious. Cantharides, or various preparations of them, as well as other substances enumerated under this head in pharmacology, are distinctly to be eschewed. Not only are they absolutely incapable of exercising any influence over the sex of the future offspring, but they can also be distinctly injurious to the whole organism, or in any case to the urinary and generative organs in this way, that, after having produced their effect, they occasion a reaction, which leads to abnormal conditions and inflammation of the kidneys. No expedient of this kind, no food of any sort, nor drink, should ever be used, without medical advice. Most of all are these expedients out of place where any question exists of determining the sex of offspring.

All these nostrums, as well as the particular kinds of food or drink, exercise only temporarily a certain influence over the activity of the sexual organs, exactly as they do in general over the

nervous condition, the mental disposition, humour, &c., which are temporarily stimulated.

Herewith may be classed the expedient of the injection of semen, mentioned by Brown-Sequard, in consequence of which people of advanced age enjoy a feeling of rejuvenescence. His first experiment was tried upon himself, and in spite of his advanced age, he felt himself quite fresh and young. Originally the injection consisted of a sort of watery extract made from the testicles of animals. Afterwards preparations were used which had been more carefully prepared. These extracts are employed by medical men under the name of spermin or orchidin.

In a similar way an attempt was made to obtain extracts and pure preparations from the ovaries of animals (oophorin), which were to be used in the same manner.

After having given ourselves the trouble to glance through the long series of different views which have existed concerning the origin of sex, we are struck with the fact, that scarcely a single objective observation has been made that could lead to a positive result in the development of sex in the new-born. Out of all these theories, how-

ever, one hypothesis does seem to be tenable, and to that we shall find ourselves compelled to give our adhesion here, after having set forth the detailed explanations which shall presently follow. Now we were not led to the recognition of the truth of this teaching by previously assumed theories. On the contrary, it was after we had completed our experiments, and had been led by them to positive results, that we found ourselves compelled, in order to find an explanation of the whole process, to fall back upon the theory of cross-heredity of sex, and to place it, by our own experience, upon firmer foundations. It must be briefly remarked here that the literature of this subject is very extensive, and to trace out all the literary results would lead us too far. For which reason I have limited myself to the actual facts.

In order to enter more fully into our theory, it will in the first place be necessary to turn our attention to the products of excretion which are eliminated from the bodies of animals in a more or less solid, fluid, or gaseous form as the results of the transformations of matter which have taken place in the bodies of the animals. The chemical constituents of the evacuations are

either such as it has not been possible to convert to use in the body, or such as are evacuated as the final product of the oxidation which has been effected in the body by the process of combustion.

Of these the former are evacuated from the body as so much inert matter which has not been affected by the digestive juice nor altered in any other way. The latter are given off from the animal's body in various states of oxidation in the urine, sweat, or dung, or else in a gaseous form by the lungs.

A great number of the substances which have been hitherto exactly examined are secreted by the kidneys and appear in the urine. In this state of fluid are found nitrogenous products of secretion, others free from nitrogen, and inorganic substances.

Amongst the substances free from nitrogen, I found myself prompted *more particularly to select as an object of my attention the carbo-hydrate (sugar) found in the urine.* Three groups of closely connected compounds are reckoned amongst the carbo-hydrates. They consist of carbon, hydrogen, and oxygen, which contain in the molecule six, or a multiple of six, atoms of carbon. The hydrogen and oxygen are in the same proportion as in water (Arnold).

The three groups are grape-sugar, cane-sugar, and cellulose. In the urine grape-sugar occurs normally among the products of excretion in inconsiderable quantities. Under exceptional circumstances, in cases of polyuria, inosite can occur (H. Voll, Neumeister). In addition we find also a carbo-hydrate mentioned by E. Luther that would be of the character of dextrine, and probably owes its existence to the secretive activity of the urinary bladder.

Upon boiling the urine with mineral acids we obtain substances which separate as brown flakes. We denote these 'humin-substances' (*Humin-substanzen*, Udránsky, Salkowski). In addition to these must be enumerated animal gum, iso-maltose, pentaglycoses, lævo-rotatory sugar, the conjugate glycuronic acids, &c. In conclusion, the occurrence of milk-sugar must be mentioned, which appears in the last days of pregnancy. The last-mentioned substances occur in very insignificant quantities, and are not to be enumerated among the ordinary constituent parts of the urine.

The carbo-hydrates may be in many respects of high interest for the activity of the organism in its metabolism, as they are found amongst the

products of excretion only as final products of the completed transformation and using-up of the food.

The excretion of a carbo-hydrate in the urine can be interpreted to mean that the process of combustion in the organism in question has not been complete. By some agencies at present unknown to us, the efficiency of the organism becomes impaired in such a way that it does not fully use up all combustible substances.

A number of substances can be excreted from the body which are capable of a further process of oxidation—for example, until they are oxidised into carbonic acid and water. The heat which could be hereby generated is withdrawn from the organism, and must be procured by fresh nourishment, in order to replace that which has been lost by an imperfect assimilation of the food.

One substance which occurs in the urine, about which much has been written by various authors, by physiologists, by medical men and by chemists, is of high importance for our inquiry. That is the *sugar found in normal urine.*

When this substance occurs in the human organism, no matter in how small a quantity, its

presence always suggests the assumption that it ought not to have been secreted in the form of grape-sugar. For, if the organism possessed its full efficiency to deal with the necessary quantity of food taken, then one might also suppose that a substance such as grape-sugar, be the quantity never so small, would not be secreted in an unaltered form, but must be further used up, seeing that the sugar would be decomposed, oxidised, in short, burnt up.

The imperfect performance of an operation of this kind by the organism is not to be taken for a symptom of pathological processes. In point of fact it has been impossible to recognise, in the case of individuals afflicted with this imperfection, any symptoms of processes of such a character as would furnish the remotest occasion for the appearance of disease.

When small quantities of saccharine matter are excreted, derived from carbo-hydrates which have been swallowed, or, on the other hand, formed within the human body, say from albuminous principles, it might be expected that this excretion, occurring repeatedly in different individuals, ought to be regarded as a

normal metabolic process. Such an occurrence must be interpreted, in fact, in much the same way as other small anomalies which affect the organism, whose presence leads to no further consequences.

But our attention must be directed, not to the sugar alone, but to a number of other so-called reducing substances; because these, as regards certain reactions, resemble grape-sugar, and have to be distinguished from it.

In the year 1858, my highly-revered master E. Brücke drew attention to the presence of grape-sugar in normal urine. The foundation of the theory of normal glycosuria was laid by his obtaining the potassium compound of sugar (*zuckerkali*) from large quantities of urine. His theory has been since much elaborated, and a great deal written both for and against it. When this symptom in the urine reaches a certain proportion per cent., the condition of the individual must be described as diseased.

If we apply qualitative chemical tests for sugar, we soon find that they are disturbed by a number of reducing substances which exist in the urine, and it is often difficult to determine whether

the processes used to discover the sugar do not produce more reducing substances than the sugar itself.

Bence-Jones agrees with Brücke's opinion respecting the presence of sugar in normal urine, and insists upon its power to rotate the plane of polarisation to the right. More recent authors, Ivanof, Huizinga, Pavy, Abeles, have stated this fact in different ways, and it yet remains to be verified. The fact existed, but not without meeting with contradiction. Maly, Seegen, Friedländer, and many others sought to oppose the view.

Although in many cases with the commonly used reactions it is impossible to demonstrate the presence of sugar in samples of urine, nevertheless, the sugar has been isolated in considerable quantities, by means of precipitation with acetate of lead and ammonia, and by subsequent decomposition analysis of the precipitate with sulphuretted hydrogen (E. Ludwig), after which it has been successfully tested and recognised by characteristic reactions.

We shall here concern ourselves principally with the appearance or the increase of the sugar,

so far as its presence according to the views hitherto held is normal.

We are acquainted with a so-called alimentary glycosuria, which is occasioned by this, that the individual in question, after having eaten an excessive quantity of sugar, easily recognises an increase of the quantity of sugar in the urine. But there are also individuals, who, though they may have eaten a very large quantity of sugar, cannot afterwards discover a trace of it in the urine. In these cases complete combustion has taken place.

But here we must also next direct our attention to the fact that there are persons who, in the digestion of their food under all circumstances, excrete sugar, though perhaps in very small quantities. Others, after eating proportionately much larger quantities, excrete no perceptible sugar in the urine. Hoppe-Seyler, after having eaten 225 grammes of sugar, could find no trace of it in his urine (Moritz). Frerichs admits exceptions, and relates that in the case of two men he could always discover sugar in the urine after they had eaten sugar, although he considered both healthy. Then we find specialists like Budge, C. Schmidt, Mosler, Schiff, Vogel, C. Ludwig, Voit, &c., who admit, after their ex-

periments with men and beasts, an artificial glycosuria, which is normal. Seegen, after feeding dogs with cane-sugar, found inverted sugar (*invertzucker*) in the urine. The sugar which he was able to identify was of two kinds, one of them turning the polarisation plane to the right, and the other turning it to the left.

Experiments with champagnes, various other wines, and sweetmeats, which contain great quantities of sugar, gave as a regular result perceptible sugar in the urine of many individuals. As a consequence of greater quantities being taken an excessive glycosuria set in. Its duration depended upon the occasioning causes alone. On their removal, the quantity of sugar either returned to a minimum or entirely disappeared.

The presence of sugar in normal human urine is therefore possible in accordance with all the above-mentioned observations. This fact must be considered a physiological axiom as regards the constituents of normal urine. The quantity of sugar contained can be increased by a condition of alimentary glycosuria. But, when there is no such artificial cause, and yet the sugar is recognisable, without the ordinary régime of life

being altered, still its presence is no symptom of a pathological process going on. Even the continuation of the insignificant excretion of sugar, when it continues for many years, appears to exercise no influence over the health. *But as one finds many individuals in whose urine not even the minimum quantity of sugar is discoverable, it seems not improbable that in a perfectly normal condition of the organism it is possible for many individuals completely to burn up the whole of the carbo-hydrates either taken into the organism or formed within it.* Such persons, in consequence of their metabolism being normal, are able to carry out the process of combustion to the full, and their excretions are of such a nature as should represent the normal processes.

But, if this condition of the excretions cannot be attained in a given individual in the desired degree, the organism is suffering from an imperfection that occurs in a normal manner (an excretion of sugar) to a certain degree and extent, such as the physiological potentialities of a living organism permit.

In one connexion only, in which it afforded me practical assistance for my observations, this question has not yet been fully elucidated. Sex had not been taken into consideration during the

examination of the excretion of sugar within normal physiological bounds. Whilst I was looking through the experiments of the specialists whom I have mentioned, it struck me that most of the inquiries respecting the presence of sugar in normal urine had been made in the case of men alone, and that, so far as regarded the presence of sugar, the urine of the human female had been little observed, and never quantitatively and qualitatively compared with that of man. Nicolai Ivanoff, in his dissertation (Dorpat) on the question of glycosuria in the case of pregnant women, lying-in women, and suckling women, arrived at the following final results: 'A physiological glycosuria in the case of the pregnant, or of those who are lying in, has, so far as present investigations have gone, never been established, and certainly not to the extent which Blot asserts. Sugar occurs in human urine more frequently than has been hitherto supposed, but absolutely never *in constant and increased quantities in that of pregnant and lying-in women.*

If, however, it has been in many cases asserted that there was an increased quantity of sugar in the urine of pregnant and lying-in women, and that this has been proved, these statements have originated from mistaking for a previously de-

veloped sugar one which has during the experiments come into existence from the action of alkalies and acids on an extractive substance which requires further examination.'

For the detection of sugar in the urine several methods exist, which are more or less sensitive.

If we mix a few cubic centimetres of urine with an equal quantity of 10 per cent. solution of caustic potash and warm a portion of this in a test-tube, we observe that the fluid in the event of a sensible quantity of sugar being present acquires a colour varying from dark yellow to yellowish-brown. We can most easily assure ourselves of this if we warm only the upper part of the fluid contained in the test-tube, whereupon the upper part of the fluid will appear darker than the rest.

This test will give a distinct result only in presence of a minimum of 1 per cent. of sugar.

A much more sensitive test consists in the reduction of a salt of bismuth in an alkaline solution of urine sugar. This test, given by Böttcher, was modified in the following manner by Nylander. Four grammes of Seignette salts are dissolved in 100 cubic centimetres of soda lye

of sp. gr. 1·119 and 2 grammes of bismuth subnitrate are added to the fluid warmed in a water bath. This solution represents Nylander's reagent.

In order to use the test we mix five cubic centimetres of the urine to be examined (which, if possible, ought not to have a specific gravity higher than 1·020), with 0·5 cubic centimetre of Nylander's reagent in a test tube. The mixture is now boiled for two minutes. If more than 0·5 per cent. of sugar is present in the urine the originally white precipitate of earthy phosphates becomes deep black; with 0·05 per cent. of sugar it shows a clearly brown colour.

If this test is not the most sensitive of all, it provides us with a process for recognising sugar in the urine, and not a number of other reducing substances mixed with it (Neumeister).

Amongst the various tests for sugar used in practice, that of Trommer is one of the most common.

We mix some 5 cubic centimetres of urine with an equal volume of 10 per cent. solution of potash or soda, and add to the mixture, drop by drop, a 10 per cent. solution of sulphate of copper,

so long as the resulting hydrated oxide of copper is dissolved by the sugar.

In this way we get, according to the quantity of sugar contained, a more or less ultramarine-blue fluid. If we warm this, the result, in consequence of the reducing action, is a reddish-yellow precipitate of hydrated suboxide of copper which, after a short time, adheres to the sides of the test-tube, somewhat in the fashion of a mirror.

This test can be applied fairly simply, and it gives good results in presence of more than 0·5 per cent. of sugar. But at the same time we cannot use it to detect extremely minute quantities of sugar such as normally occur in human urine, because the urine, as we have already remarked, contains a number of substances which reduce alkaline solutions of copper.

The effect of these substances is sometimes such as to produce the illusion that from 0·3 to 0·5 per cent. of saccharine matter is present (Neumeister).

In recent times, for qualitative and quantitative investigation of the grape-sugar, much use has been made of graduated fermentation-tubes.

For this experiment we mix about 10 cubic centimetres of urine with a small quantity of

yeast of ascertained weight, and fill the fermentation-tube with the mixture. After the lapse of twenty-four hours, during which the whole is kept in an incubator at a temperature of 30° centigrade, all the grape-sugar will be completely fermented.

From the gaseous fermentation products of the grape-sugar, which rise into the longer branch of the U tube, and consist of carbonic acid, we detect the presence of sugar in the urine.

By means of the graduation of the longer branch we can at once read off the percentage of the sugar. This test is sensitive enough to detect 0·05 per cent. of sugar. It is useful first of all to boil the urine to be tested, in order to remove from it the carbonic acid contained in solution. It is also advantageous to acidify the urine, so that the yeast fungus which flourishes more easily in the acid medium may overpower any gas-producing bacteria, and so avoid a false result.

In 1884, E. Fischer discovered phenylhydrazin, and pointed out the fact that it might be used as a valuable reagent for the sugar in urine.

This preparation has the characteristic peculiarity of forming crystalline compounds with aldehydes and ketones. These crystals, in the cases of the different kinds of sugar, which, as

is known, represent the aldehydes and ketones respectively, are needle-shaped, of a yellow colour, with difficulty soluble in water, have a high melting-point, and are called glycosazone.

Jaksch used this property of phenylhydrazin for his phenylhydrazin test. For this experiment he dilutes the urine with an equal quantity of distilled water in a test-tube, and adds twice as much phenylhydrazin hydrochloride as can be taken up on the end of a knife, and double that quantity of sodium acetate. The mixture is well shaken together and left from half-an-hour to an hour in a boiling water-bath.

Then, if the test-tube and its contents be slowly cooled, at the end of about twelve hours the sediment is found to consist partly of spherical resinous lumps, and partly of microscopical tuft-shaped crystals.

These crystals are nothing else than glycosazone-compounds (Moritz). In normal urine this reaction is very often observed as distinctly evident as if we had to do with a urine containing as much as 1 to 2 per cent. of sugar.

In reality besides the extremely minute traces of grape-sugar, a whole number of aldehydes and ketones are present in urine, which can form phenylazone.

Amidst all these substances those which, according to the investigations of Flückiger, chiefly interfere with these tests are the glycuronic acid compounds, as they give crystals of the same form in the course of the reaction. Flückiger detected these compounds by their property of rotating the polarisation-plane to the left, and reducing alkaline solutions of copper after long boiling. More accurate investigations enabled him to identify these substances with acetone compounds.

Moritz recommends the following method of discovering whether we have to deal with grape-sugar, glycuronic acid compounds, or other (azone) crystal-forming substances.

Several litres of normal urine are precipitated with lead chloride and filtered; the filtrate is precipitated with ammonia, and again filtered; the residue in the filter is washed and then dried on a clay slab. It is after this decomposed with oxalic acid, mixed with acetate of lead in excess, and the filtrate is deprived of its lead by hydrosulphuric acid. As a result is obtained a perfectly clear fluid to which the phenylhydrazin test described above is applied.

The precipitate obtained is filtered off, repeatedly washed with chloroform and alcohol,

several times crystallised, and finally the melting-point of the needle-shaped crystals, which can be seen with the naked eye, determined. If sugar is present, the melting-point of the crystals will be at a temperature of 205° centigrade. If the melting-point lies below this temperature, we have to do with other substances (azones).

Hence it appears that we possess in the phenyl-hydrazin test, applied in the manner above described, a certain method of detecting even the faintest traces of sugar in the urine.

Although hitherto it has been often ascertained that sugar was present in normal urine, that was demonstrated only by the other methods with which we have been hitherto acquainted, and not by means of the phenyl-hydrazin test in the manner in which we have explained its use. This seems to have been the reason why different authors have not been able to speak unanimously on this subject.

It frequently happens that the sugar is present in such quantities that we are able to observe its power to rotate the plane of polarised light.

For this purpose we generally use Soleil-Ventzke's penumbra-polarisation apparatus, a

description of which will be found in the handbooks on the subject.

This apparatus suffices to investigate the dextro-rotatory and lævo-rotatory substances in the urine. With its assistance it is also possible to determine the quantity of sugar in the urine. In addition for the determination of the quantity of sugar in the urine a number of chemical processes can be employed, such for instance as Fehling's method with Worm-Müller's modification, Knapp's method, and various others.

If we add to normal urine a dilute solution of potassium permanganate it at once loses its colour. From this we perceive that the urine contains a great quantity of oxidisable or so-called reducing substances.

It has been already mentioned that Trommer's test gives positive results after protracted boiling even in the case of normal urine, without any corresponding quantity of grape-sugar being present. In this case the reducing substances interfere with the test in consequence of their tendency to become oxidised.

We find a number of them in the urine. Foremost among them are uric acid, creatinine,

and the colouring-matter. Also the substances mentioned above in the description of the carbohydrates have reducing properties.

Different statements have been made as to the quantity of reducing substances existing in the urine. According to Flückiger they form from 0·15 to 0·25 per cent.; according to Salkowski an average of 0·4 per cent.; and according to Munk an average of 0·3 per cent.

Moritz found the quantity of reducing substances range between 2·93 and 4·1 grammes per diem in a grown man. His investigations were made with the collected urine of 24 hours, and were applied to that of men, women, and children. The result showed that men always excreted a greater quantity of reducing substances than women of the same age who used the same food.

The quantity of these substances depends upon the food taken. An increase is also possible when certain benzoin compounds are taken into the system. Moritz also found that the ratio of the quantity of reducing substances to the food was a constant, which is the case also with the nitrogen evacuated. An increase of the daily

excretion of reducing substances follows the free use of albumen.

If, in the case of an ordinary diet, such as men take in youth, the body performs its labours without fatigue, it must be assumed that the several food stuffs have been selected from the classes of albuminous bodies, carbo-hydrates, fats and inorganic elements in suitable portions and are provided in sufficient quantity.

According to the statements of Pettenkofer and Voit the total metabolism is greater during labour than during rest. The food requisite for a normal grown man while in a state of rest may be reckoned at 30 units of heat for each kilogramme of weight. In the case of a full-grown working man, whose weight was 70 kilogrammes, the necessary food represented about 2000 units of heat. For a person whom we, following Voit, will describe as an average working man the requisite food supply consists of 118 grammes of albumen, 56 grammes of fat, and 500 grammes of carbo-hydrates, equivalent to 3055 units of heat gross, or 2749 units of heat net.

As woman is generally smaller than a man, and the weight of her body also less in comparison with his, and her labour also less than

that of a man, if we compare men and women of the same age together, it is obvious that in her case a less provision of force, and in consequence less food, under similar circumstances, is necessary than for the man. Voit assigns to a working woman a food supply of 94 grammes albumen, 45 grammes fat, and 400 grammes carbo-hydrates, which correspond to 2444 units of heat gross, and 2200 units of heat net, whilst the whole of the food taken by an average working man according to Voit, is fixed at 118 grammes albumen, 56 grammes fat, 500 grammes carbo-hydrates, equivalent to 3055 units of weight gross, and 2749 units of weight net.

Many consider that the quantity of albumen is placed too high. For this reason Munk assigns a lower quantity of albumen for the food. Yet the numbers which he gives do not vary much from those of Voit.

In youth several very marked differences appear in the metabolism, and especially in the quantity of carbonic acid given off, and these differences appear in both sexes (Tiegerstedt).

In the case of a male individual from fourteen to nineteen, the quantity of carbonic acid given off is greater than in the case of those who are younger or older of the same sex.

During the same years also a more rapid increase of weight takes place, and a marked increase in height. This shows an increased metabolism, which is occasioned by the greater addition of substance to the body.

In the case of the female individual this increased excretion of carbonic acid does not occur at the same age. A girl of eleven gives off nearly the same quantity of carbonic acid as a grown woman.

The quantity of carbonic acid given off by both sexes shows that, at like ages and under like circumstances, the quantity given off by men in their younger years is considerably greater than that given off by women.

When the time of the increase of the body is completed, at the end of the period of growth, with both sexes there is little difference between the ingesta and the egesta. The difference also between the sexes is much less, and in advanced life completely vanishes.

It will be seen from the above brief statements respecting metabolism in both sexes that a difference is perceptible, and this implies the possibility of carrying out an attempt to express

that difference numerically. It would lead us too far were we here to set forth all the consequences connected with these facts in the case of both sexes with reference to growth, physical condition, &c. These are sufficiently known from the data given in other technical works which treat of the characteristic differences between man and woman in different ages.

I shall here call attention to one peculiarity only of the human female, which is this, that the female organism, in consequence of the less abundant formation of tissue, is on a smaller scale than that of the male, and yet the amount of sugar given off in the urine is, under normal circumstances, nearly the same in quantity as in the case of the male.

Where there is less abundant formation of tissue there must be evidently less strength. Consequently a weakness in the organism, such as is present where we find the normal excretion of sugar, will have a more marked influence upon the work done than a greater weakness of the same kind would have where the mass of the body was greater and the matter taken for combustion greater also. In other words, the sugar excreted in a normal way in the urine of the man does not indicate so significant a loss of

the heat produced by combustion as it indicates in the case of the woman.

When, in addition to this, a woman is in the earlier period of her life, at which time an ovulation takes place regularly every month, it is not a matter of indifference whether a good and complete use is being made or not being made of the matter taken as nourishment.

Also, though the excretion of sugar in insignificant quantities in a normal way is not detrimental to the whole organism, yet it appears, as we shall see presently, not to be a matter of indifference as regards the ovum forming itself and ripening in the human female.

Now, if we take further into consideration the observation which I made many years ago, that sugar often occurs in the urine of women, and also in larger quantities, than we observe in the case of men, it is obvious that this symptom ought to arrest our attention. Certainly we often meet with female urine which shows us clearly that the process of combustion in the organism in question is being perfectly effected. Practically in such urine no sugar is detected by the reactions which have been mentioned above, not even by the phenylhydrazin test. Yet, in the case of many of these women,

although no change has been made in the diet, sugar is found in the urine temporarily in inconsiderable quantities shortly before and shortly after menstruation. The methods of investigation which we have applied gave at these epochs a positive result.

The appearance of sugar in the urine does not occur only amongst women of the upper classes, who enjoy a better and varied diet, but also amongst those of the poorer classes, who are obliged to subsist chiefly upon vegetable food.

Indeed in the case of vegetarians who take concentrated albuminous substances only in the form in which they occur in eggs, and get animal fat and sugar from milk alone, the urine, as regards the occurrence of sugar, is of the same character as that of those who do not adhere to vegetarianism. Women, who, in other climes, are not within the reach of our investigations, might also be included in the same category so far as their diet is concerned.

It follows that the individual does not excrete sugar only in consequence of the character of the diet, but that the *processes of combustion* manifest

themselves in the results derived from the digestion of the different nutriments.

Now, an indispensable condition of the ripening of the ovum in the female organism is that the metabolic processes shall be normal. When these changes are being effected as perfectly as possible, sugar is entirely absent from the urine. The female individual may have arranged and chosen her diet from the different groups of food in any conceivable way, and she may belong to this or that class of the community, but the metabolic processes—that is to say, the combustion processes—are nevertheless those which deserve most attention in connexion with the development of the ovum.

Ovulation is never in any case altogether independent of the influences of diet and metabolism. In those cases where the combustion is of such a kind that unoxidised remains of bodies still capable of producing heat are found in the urine, the ovum in process of development in the human female is never so highly developed as in the cases where no sugar, or at least no recognisable trace of it can be found in the urine.

In the first case we shall have not only a less

ripe ovum, but very likely also a less well nourished ovum. An ovum of this sort has not so fully attained to all the characteristics and powers inherent in its protoplasm, and, in consequence, seems fitted to develop only a female individual. In such an ovum the several cell-products of the ovum, which have to develop themselves into the future embryo, will be arranged for the growth of a female. Not only will female organs of generation be developed from it, but also all the elements of the future individual will be feminine.

On the contrary, if in the mother-individual all the substances developed in, or taken into, the organism *undergo combustion in such a manner that no sugar is found in the urine, not even in the smallest quantities, then an ovum can be developed such as is required to produce a male individual. Out of its protoplasm in the course of evolution elements form themselves, whence male cells are developed, which correspond to the development of tissues and forms of the male individual. Some of the cells—viz., those which ultimately become the elements for the continuation of the species—are planned for the male sex.*

It follows from all this that the result depends to a great extent both upon the diet chosen, and upon whether it has been rightly chosen to suit the

organism, whether it is possible to exert such an influence as may so support the ovum in its maturation that in its development it may form itself into a male individual. It must be observed in advance that such an influence as may be effective for the production of sex must not be applied to an already fertilised ovum, but must be applied to an ovum in development before its fertilisation.

Indeed, it is even of greater importance to know that the mother individual has been for a considerable period anterior to the fertilisation of the ovum provided with the requisite food. Care must also be taken that *after* conception a similar befitting diet is continued for the mother, which diet should resemble that previously provided.

Of what sort must the chosen diet be which can favour the ripening of the ovum? Always only such a diet as can so modify the process of food assimilation in the organism that no excretion even of the most minute quantity of sugar discoverable by the application of the phenylhydrazin test can be detected.

The quantity of sugar is small, but what has

to be taken into consideration here, is not so much the amount of the sugar, as the fact that this substance is being excreted.

Now it has been proved by experience that when in an organism a symptom appears, as the evidence of disease, in the form of a considerable excretion of sugar in the urine, it is in many cases possible, by the means of fitting diet, to produce a diminution of the excretion of sugar, either bringing it down to a small amount, or causing it to disappear altogether.

Investigation of the urine according to recognised methods must accompany this system of diet, and, under normal circumstances, we soon meet with the phenomenon, at which we have been aiming — that the quantity of sugar has diminished to a no longer perceptible amount. When this has been attained, it may be presumed that, by a further perseverance with the same diet, the metabolism will be so regulated that, if no pathological accident supervenes, the excretion of sugar will cease. In fact, in consequence of an alteration of diet and the taking of no excessive quantities of starch and sugar, the excretion of sugar in the urine ceases for a considerable time, and only makes its reappearance after a long interval.

When, in consequence of having observed the minute normal quantity of sugar in the urine, my attention was attracted to the fact that the determination of the future sex was connected with the presence of this sugar, my endeavours were directed to exercising such an influence over its presence as might enable me to get rid of it. Experiments with the most diverse diets gave me in the case of women most remarkable results. In this way I found women, using an almost exclusively flesh diet (which was of course especially rich in nitrogen), whose urine showed greater quantities of sugar — according to approximate estimations — than when they used a diet of carbo-hydrates, that is, sugar, fatty substances, alcohols, &c. Others, again, showed an exactly opposite result. In many cases I did not succeed in getting rid of the normal sugar in the urine; in others it disappeared soon after the beginning of the treatment. It follows that, in every case where the question is one of so influencing the sex that a male offspring may be obtained, the very first thing to be determined is whether the normal quantity of sugar is present in the woman's urine or not. If none can be detected after repeated and painstaking search, and if reducing substances are plentifully present, we

do not require to change the diet, but can recommend immediate impregnation, as every probability points to a male embryo. But in all cases where the normal 'urine-sugar'—if I may so call it—is present, even if only traces of it are to be found, it will then be our task, by various alterations of diet, to discover that one which seems suited to the organism in such a way that it will occasion the disappearance of every trace of the 'urine-sugar.' In these experiments the remarkable phenomenon is observable, that the reducing substances which I have already mentioned, and amongst these especially the lævorotatory glycuronic acid compounds show alterations in respect of quantity.

In fact, I found that the urine of most women who had male offspring contained, during the first months of pregnancy, more reducing substances than the urine of women who had female offspring. It is, therefore, also necessary that the diet should not only occasion a disappearance of the normal urine-sugar, but should also produce an increase of the reducing substances. This end can be accomplished certainly also by the use of different medicines, such

as chloroform, turpentine, salicylic acid, &c. But, apart from the fact that medicinal influences are distinctly to be discouraged, these substances do not seem to produce the same effects as diet. Besides, it is still a question of what kind these efficient substances are. And another question is whether they are themselves effective. It will be sufficient for us to recognise them as a symptom.

It is known that the male sex possesses a distinctly greater amount of albumen than the female. In age this difference disappears; in youth it is greater. It might be expected that male offspring would result, in consequence of a more albuminous diet, by which a greater increment of albumen would be made possible; the thing, however, is not quite so simple as this. Investigations in various cases showed me that women in whom an increased amount of albumen could be detected, but in whom either sugar was present to a small extent or, on the other hand, only very small quantities of reducing substances could be detected, almost always had female offspring.

In spite of many endeavours to elucidate this phenomenon, I was forced to have recourse to the symptoms alone, and to hope for the production of the male sex only from the disappear-

ance of the sugar and the increase of the reducing substances. Certainly, further investigations showed that the same diet which was the most favourable to the production of the condition which I have named (the disappearance of the sugar from the urine and the simultaneous increase of the reducing substances), also effected the best albuminous increment in the body. Key's statements teach us that male individuals put on more albumen than females, and that this is especially the case during the period of growth. Very likely the male embryo also requires a greater amount of albumen than the female, in the same way as this difference exists between the boy and girl.

We know as a universal rule that where there is rest there must be a balance of forces. If the ovum, the accumulator of the balanced forces, in a state of rest, is to divide itself so as to produce in this way the future individual, some stimulant impulse, some energy is absolutely necessary to disturb the balance of forces, and to induce the development of the cells. This impulse may be such a one as occasions destruction. But it may also be one that gives occasion to new growth, to tissue formation (W. Haacke),

We must describe this impulse as functional, and recognise in it a peculiarity which belongs to the organic world alone, the vegetable and animal kingdom. Every movement, every use of an organ may serve as a stimulant impulse and contribute to its development. Thus we find, in the case of great thinkers and poets, of celebrated generals, &c., a powerfully developed brain. Oarsmen, gymnasts, and swimmers have far stronger muscles than men who follow less fatiguing callings. In all these cases there are impulses leading to increased growth of the organs. In the growth of the fertilised ovum we have to deal again with a phenomenon of impulse, a part of which is the property of the ovum itself, a part, however, also dependent upon external influences. We call the former autoplastic, the latter xenoplastic impulse (Haacke). It is easy to understand that a purely autoplastic development (*eine reine Autoplasie*, a pure autoplasia) cannot exist. Out of an ovum alone, without the agency of new impulses, without the taking up of new matter, no new individual could develop.

The stomach furnishes the gastric juice. It is stimulated to do so by the food. The food is

digested, undergoes absorption in the intestine, and becomes lymph. Blood is formed. The blood passes through the several organs and tissues, nourishes them, and replaces the substances used up by work. As soon, therefore, as the stomach and intestine, with the intestinal glands, fail in their functions, all the organs, which stand in physical relation with them, suffer; because they are constantly during their work consuming matter, and are now receiving no fresh supplies. The case of the other juices of the body is the same. The thyroid glands supply the body with a principle without which a person cannot be in a normal condition. Similarly the testicles, as glands, supply the body with a principle the want of which gives a man distinctly female qualities, as we perceive in the case of eunuchs.

There is no doubt that the males and females of a race of animals develop out of the same germinal matter. Its development depends upon two important factors, the impulse, and the capacity to take up matter conditioned thereby. By taking up matter the substance of the newly developed cells is increased, and this in turn prompts them to repeated division, until at last an organ is

developed. The new organ again furnishes new impulses, and so influences the development of other organs. The impulses are of themselves physical and chemical (Haacke). In the ovule and the embryo the impulses are what chiefly bring about new growth. These impulses the ovum receives from the mother whose product it is. Now, as of the most different impulses now one and now another comes to the front, the embryo will acquire at this time rather these qualities, and at that time those. The impulse will occasion now a greater addition of matter to this organ, and now a greater addition of matter to that. According to observations made up to the present time, there is hardly any doubt that the development of the organs of sex requires an impulse as does the development of all the other organs. These sex-determining impulses originate, like the other development-determining influences, from the mother, since it is she that supplies to the embryo, as agencies of impulse, the juices derived from the food which she has taken. In addition to these, the embryo receives also from the mother such products as are required for the growth that follows the impulse. If the mother gives the child no material for growth and no impulse, then the child, since it is dependent upon

the mother, must perish. Now, according as a developing ovum or an embryo either receives the juice, the means of impulse, for the acquisition of the male sex, or for the acquisition of the female sex, so will a male or a female result.

Of what kind the means of impulse are, the juices are, which occasion this I do not know. I can only supply the conditions requisite for them; I can see only whether they are present. And so I again come back to this, that we may expect a male individual from the ovum when the juices are developed which serve as a functional means of impulse for the male sex. These juices can come into existence in the organism under the most different circumstances. But they certainly do come into existence, if we can so feed the mother that we cannot find in her urine even the faintest trace of sugar, but instead of it an increased excretion of reducing substances, *accompanied by a relatively high exchange of nitrogenous substances*. These facts can, therefore, serve us only as a symptom of processes taking place in the organism. In consequence our task will be to follow up in the various cases the conditions of this symptom, *in order that we may try so to feed*

the mother individual that she may attain to giving the effective impulse; and this we have certainly accomplished by the increased excretion of the reducing substances and the disappearance of the normal urine-sugar.

When we have brought a woman into such a condition that she excretes no sugar, and by the continuation of the same diet keep her permanently in that condition, the ovule which is being developed in her organism will develop itself correspondingly. Also with this diet the different qualities of the organism may not be altogether without influence on the course of the ovum's development.

In many cases the quantity of sugar in the urine excreted does not diminish. The most different kinds of diet may be tried, and yet the phenylhydrazin test will always show the presence of sugar. Individuals of this sort exhibit a certain obstinacy in resisting the attempt to procure an alteration of the metabolism. In such cases no influence has been exerted over the development of the ovum.

In these experiments which are made with the mother, not only is the ovum influenced

which is being developed for fertilisation in the maternal organism, but it is also possible for the mother herself, in consequence of the alteration of diet, to experience many changes with regard to the physical peculiarities of the elements which compose her body.

The treatment may prove highly beneficial to the mother herself, so that not ovulation alone is subjected to an alteration, but the activity of the processes of the tissues of the other organs of the body may be also simultaneously in some way changed. And here may come into consideration many other factors which may produce a particular fitness for procreation and for the development of the ovum, and, if they once make themselves felt, may be of the greatest advantage to the mother.

The formation of the insignificant quantity of sugar in the body goes on of itself regularly, without it being possible to perceive any consequent striking alterations in the organism. The manner in which sugar is formed in the body under normal conditions has in recent years been thus explained.

The sugar contained in the blood in healthy persons is reckoned as not higher than about 0·15 per cent. In those who suffer from dia-

betes it may rise to 0·44 per cent. If sugar is present in the blood, that it passes thence into the urine can be easily explained, seeing that the excreted products of decomposition from the blood pass into the urine. Thus the sugar results from a portion of the food which is transformed into sugar, and so passes into the portal vein (Strümpell).

There exists also in the liver and muscles a non-nitrogenous substance, glycogen, which is detected also in other organs. This glycogen probably arises partly from the carbo-hydrates of the food, but certainly from the albuminous substances taken with the food, which, when broken up, separate into nitrogenous products and glycogen.

When the glycogen is once formed, we may regard it as an intermediate substance which is changed into sugar, probably by a saccharine fermentation, and then can reach the blood. How glycogen is transformed into sugar within the organism is unknown. Normally occurring sugar results from glycogen.

CHAPTER III.

When, years ago, my attention was first attracted by the idea that, for the solution of our problem, we ought to turn our attention to the sugar in normal urine, no very exact tests for sugar were possible. The reactions were not very sensitive, the fact being that the surest evidence of the presence of sugar was obtained not from the reduction processes, but from the method used by Brücker for preparing a potassium compound of sugar.

Every investigation which I undertook in his times for the confirmation of my theory was very arduous. The few cases which I at first had under observation presented formidable difficulties. The occasion of my first turning my attention to sugar in the urine was a case of a woman who had borne five children, and, after violent and continuous mental excitement, was suddenly seized with diabetes mellitus. I frequently examined her urine, and always found an abnormal amount of sugar. She had twice given

birth to children whilst suffering from diabetes, and on each occasion the child was a female. This fact struck me, because previously, whilst she was strong and well, she had borne sons only. But, on the appearance of the disease mentioned, she had two daughters in succession, of whom the first one lived and the other was still-born.

I numbered amongst my acquaintances a family, of whom, in the course of years, I was acquainted with the grandmother, a daughter, and two grand-daughters. The grandmother had, including the third generation, fifteen descendants, of whom twelve were girls and three were boys. Two of the boys were the sons of the grandmother, and the first two children she had borne. She was under medical treatment, and the analysis of the urine showed a considerable quantity of sugar. She had six daughters. One of these daughters, who survived the others, had five children, amongst them one boy, who soon died.

Two of the grand-daughters of this family became mothers, each bearing one daughter. I had the opportunity of examining the urine of all the mothers of this family, and always found sugar in it. Sometimes the saccharine contents

reached a remarkable quantity, and yet were not such as could be diagnosed to indicate an unhealthy condition.

Amongst the acquaintances of my youth was a young lady of good family. Carefully reared, she was, as a child, too much sheltered from the influences of the open air, and in later years much imprisoned indoors by hard study in different branches of art and science. As a young lady she was fairly tall and well nourished, but pale and possessed of little colour.

It happened that I had an opportunity of examining this young lady's urine. As I found a considerable quantity of sugar, I was led to the conclusion that the girl (she was engaged) would have principally female offspring.

Many years had elapsed. The young lady had ripened into a stately matron, and told me that she had the happiness to be the mother of five daughters and a son. I am altogether without the statistics necessary to deduce from a great number of similar cases the average relative number of the sexes born of women suffering from diabetes. But this must be pointed out, that, notwithstanding the high percentage of sugar excreted in the case of women suffering from pronounced diabetes, female offspring do

not necessarily always appear. They will probably be in a very striking majority when compared with the males, but the complete disappearance of the male sex is not to be anticipated, because male individuals, though in the minority, can appear. And this was to be anticipated, seeing that in the so-called slighter cases of this complaint the abnormal metabolism can be sensibly improved by attention to diet.

Diabetes amongst women has a marked influence upon the functions of the sexual organs. Thus, for example, the menses cease, a condition which, according to gynæcologists, is occasioned by an abnormal condition of the womb and of the ovaries which become atrophied (Schauta). On the other hand diabetes may also result from diseases of the reproductive organs (Imlach). When the cause of the complaint is removed from the female genitals the sugar also disappears from the urine.

From both of these facts, which rest upon medical observation, it follows that the excretion of sugar has some definite connexion with the processes at work in the female generative organs. In the cases when the excretion of sugar continues

for a considerable time, it is of greater significance, and indicates chronic derangement of the metabolism, in connexion with which a serious change comes over the internal organs of generation.

Now, if there is a possibility that disturbances so extensive can be set up in the female genital tract when there is an excretion of sugar, it is also very possible that certain modifications may be produced by a small *constant* excretion of sugar. These changes can show themselves in the ovum to this extent, that they may be of considerable significance and not without influence upon the development of sex.

Women who suffer from pronounced diabetes frequently miscarry. In what way the disease influences ovulation I cannot here discuss.

The connexion of the development of sex with an imperfect physiological combustion of the food can only be considered as demonstrated, if it is possible by means of certain exact experiments in this direction to reach results which incontestably make for the possibility of influencing sex. Cases of this kind, in which the work of observation was

conducted by myself alone, and in families closely connected with me, where there were exceptional wishes in this direction, I shall mention presently.

Most striking of all are the cases where a number of daughters have come into the world one after another as the results of a marriage.

The condition of a woman in a well-regulated married state, *when, as we will suppose, five or six girls are born, one after another, must be considered to be of a kind that departs more or less from the normal.* The human female if we regard the general statistical data ought to bring forth approximately the same number of male and female individuals. If we find so remarkable an excess in the direction either of males or females, that six or seven of the same sex follow one another, there must be a reason for this. In my opinion that cause is now to be ascertained only from the results of analysis of the urine for sugar mentioned above.

In the cases where we have to deal with an excessive predominance of female offspring, Trommer's test will show us the presence of sugar. But it is safest, as I have already said, to use the phenylhydrazin test in the manner described. If it be demonstrated that in any such case sugar practically exists in the urine, in never so small

a quantity, dietetic treatment is to be resorted to, until even the minutest trace of sugar has been made to disappear.

The treatment consists in giving the mother a highly nitrogenous diet with fat, and adding only so much carbo-hydrate as is absolutely necessary to prevent its want being felt.

This diet should be continued for a considerable time, even although the sugar in the urine may have disappeared. It is best to begin the change of diet a good while (about two or three months) before impregnation. During the menstruations which fall within this period, the ripened ova will be voided unfertilised, and new ova which have been influenced by the altered conditions of nutrition in the organism will ripen in their place.

(If we follow such information as we have concerning the development of sex in man, we thence conclude that the difference in sex appears at the beginning of the third month of pregnancy, and is definitely expressed in the fourth month. From this it would appear not to be superfluous if the recommended alteration of diet was maintained until the beginning of the third month.)

When the ovule of a human female, dieted in this way, becomes fertilised, it has been so far

ripened by the process of nutrition conducted in the organism of the mother, that when it attains the stage of development, it resolves itself into cells which compose an organism containing male characteristics.

After impregnation it is still advantageous that whilst the condition of the urine is examined at intervals of a few days, the corresponding diet should be continued during the advancing stages of the development.

Although I do not here take the trouble to illustrate these diet processes by explanations, every one can have regard to these particulars for himself, and conduct the diet even after impregnation has taken place in accordance with the information given above.

In a case like that mentioned where, after marriage, female ova were successively formed and developed, practically a process of physiological combustion was going on in the mother which did not suffice for deriving all the advantage possible from the food, so that the available elements might be all oxidised. In consequence only female ova were fertilised and only female individuals born. This condition of things remained the same for a number of years.

In such a case the question is not alone one

of a small residuum of sugar, but in addition to this it is probably not impossible that other substances also were evacuated from the body to make use of which was not within the power of the process of combustion.

With a rational diet, these substances also might be withheld from evacuation and, as well as the sugar, be made available for combustion with a corresponding increase of nourishment.

In experiments of this kind metabolic activity will show itself in the organism, as it may be perceived from the nitrogenous constituents of the urine that a greater exchange of nutritive matter is taking place, a thing that happens also with normal individuals.

Under these circumstances the specific gravity of the urine is also increased, and it may sometimes become relatively considerable (1030 to 1035).

In consequence of the influence which the altered diet, if commenced a sufficiently long time before conception, exerts both over the mother and over the ovum which is being prepared for fertilisation, it is possible that this ovum may develop itself into a male individual.

It also sometimes happens that, even with careful dieting, the conditions which are neces-

sary for our purpose are not realised — viz., that the sugar does not disappear from the urine, that the mother cannot accommodate herself to a diet of the kind required. She finds the situation intolerable, because she cannot do without an abundance of starchy substances and sugar, and in consequence all hope of a satisfactory result falls to the ground.

There are persons who from their youth upwards have lived principally on vegetable food, and are therefore not accustomed to take the nitrogenous substances of their diet in the concentrated form in which they are presented in the albuminous constituent of meat. They obtain the necessary nitrogen for the body from large amounts of food containing a great quantity of water, and it may happen that they cannot easily submit themselves to such a change of diet without pernicious consequences. To this class belong the women who live in the rural districts of many of the mountainous regions of central Europe, where little flesh is eaten. With them it might often be a difficult matter to make an abrupt change of diet of the desired kind. Such individuals can be reconciled to the kind of diet we recommend only by a gradual advance in the quantity of concentrated nitrogenous food. But

in such cases it might very likely prove possible to attain our end by a corresponding vegetable diet.

The following case, which was conducted under my control with the greatest care, and was also a case of an intelligent woman, who showed the greatest willingness to do anything in order that she might have male offspring, is of the highest interest for our theory.

This woman was of a family in which principally female children had been born. Although all its members were fruitful, no great number of descendants seemed to have been reached. It is not unlikely that the multiplication of descendants was restrained. The existence of a tendency to provide female ova for fertilisation was also proved by testing the urine for sugar.

In the case of this woman who wished to have male offspring, the examination of the urine each time showed, as with the other women of the family, traces of sugar. With her ordinary diet sugar was found in the urine (that of twenty-four hours being collected) in minute quantities. The unoxidised minute traces of sugar signified imperfect combustion.

When the diet is to be altered, it is necessary

to select it in such a way that the nitrogenous substances may predominate and that the carbohydrates may be excluded as far as possible. Of course a sufficient quantity of fat must be added to the food.

The food to be taken was regulated on these principles, and the dieting began. After eight days the last traces of sugar in the urine had disappeared. The woman's health was good, and she at once showed herself contented with the highly nitrogenous diet.

The menses lasted five days, and after them, five more days having elapsed, impregnation took place, the same diet continuing. After about eight weeks of pregnancy the food was gradually altered. The state of the woman's health during pregnancy presented no remarkable features. She had taken all necessary care of herself, and her condition during the pregnancy, in like manner as before it, when she had to alter her diet until the sugar disappeared from the urine, was satisfactory. She was in due course confined of a boy.

A year and a half passed. The woman bore, after similar treatment as on the former occasion, a second boy. In the interval no further control was exercised over her way of living, but a few

weeks before she conceived means were taken to regulate her diet so that no perceptible trace of sugar resulted from its physiological combustion.

During five years this woman did not conceive. The results of examinations of the urine, which were made from time to time, showed quite clearly that sugar was always normally present. The quantity was not determined. At the end of this period the woman, after a long rest, and a similar preliminary dieting, once more became pregnant. This time also the result was a boy. After two years another boy followed. In this case also a similar process of dieting had preceded.

After such occurrences it was sufficiently demonstrated that it could be only the influence of the diet that showed itself in this way; because in this case one would be convinced that it was not a mere accident that the woman here spoken of produced only male offspring.

In the case of this woman it was evidently the diet that affected the development of sex, and exerted such an influence, that under the improved conditions the metabolism both in the mother, and in the ripening ovum preparing

for fecundation, took such a form that a male individual was developed.

She again became pregnant after a lapse of two years. Before her pregnancy the same system of diet was followed as on the previous occasions. She miscarried in the fifth month. Violent emotions and mortifications, accompanied by anxious cares, were, together with other coincident unfavourable circumstances, the cause of the miscarriage. The offspring was male.

Soon after, some four months after the miscarriage, she again became pregnant. Also on this occasion dieting had preceded, such as I have frequently carried out for the development of a male individual. But a miscarriage again supervened. The fœtus was obviously male.

But what was now wanting was an experiment that could be added to the preceding, and would serve to show that a human female, who, under the influence of our method of dieting, invariably bore sons, would, in the case of paying no attention to diet, bring a female into the world.

The evidence was forthcoming, for the woman in question again became pregnant without any

consideration being bestowed on her bodily condition, and without anything being done to remove the traces of sugar from the urine. After having seven times borne males she became this time mother of a female, which, born before the due time, soon died. After that she was not again pregnant. Probably some change supervened in consequence of which she became permanently unfruitful.

This incident shows sufficiently that the ovum in the case of the woman who served for our experiment possessed an inherent tendency to develop into a female, and was also ripe enough to be fertilised. As we had exercised no influence upon it so as to effect any change in the ovum (in the same way as we had previously been able to affect the others by the diet in order to procure the ovum of a male) the result was a female.

The female tendency was therefore already present in the ovum, and indeed the mother supplied convincing evidence of the female constitution of the ovum whilst it was yet unfertilised, because sugar existed in her urine. The previous determination of the sex could also in this case present no difficulty. In the earlier

cases, when male individuals followed one another, we always aimed, by the medium of support given by means of the nourishment of the mother, not only at the ripening of the ovum which was to be fertilised, but also at the development of a male individual. In the last case the ovum was, without any assistance, capable of being fertilised, but it developed into a female.

A ripe fertilisable ovum in the ovary of a woman whose urine habitually contains sugar has a tendency, when the proper conditions are supplied, to develop into a female. In consequence, it is in such cases from the outset possible, without exercising any influence over the mother, without adopting any diet, to anticipate after a conception the birth of a female individual. But if these conditions do not exist, if no sugar can be detected in the urine, the use of the same influence in order to obtain a male individual is still not superfluous. In this case also there is a need of an alteration of diet, although the individual in question accomplishes the process of physiological combustion in a manner which must be called the most favourable possible, seeing that with a mixed diet all the oxidisable materials are completely used up.

Supposing that a mother of this sort wished

for female offspring, one would not be in a position to give any advice. In this case one cannot, according to the facts which have been mentioned above, exercise any influence over an alteration in the course of the development of the ovum which would occasion the birth of a female. Such a mother is, up to the present time, beyond the reach of an influence that can affect the development of the future sex.

Two other cases follow in which male children were desired, several females having so far been the offspring of the marriage. The corresponding arrangements for the regulation of the diet, which led to the complete disappearance of the sugar from the urine, showed themselves effective in the ripening of the ovum, and, after conception had taken place, in both cases a male individual was formed and developed.

In addition to this, four other cases were under observation, in which no influence was exercised on sugar occurring in the urine in quantities, such as correspond to a normal healthy state. Without any kind of influence of diet, three females were born.

In a fourth case I had a negative result. In

three cases the result was positive. In the last three cases I was able to examine the urine as often as I wished, whilst in one case I was allowed to do so only at long intervals as a favour.

Let us now in conclusion endeavour to make some short reflections on the results which we were able to attain.

First of all one would say that in certain regions and among certain peoples, where meat forms the principal diet, only male, or principally male offspring would be anticipated.

The nutrition of the mother certainly plays a leading part in the development of the ovum within her body. The different experiments which breeders have made, and the observations which have repeatedly shown in the case of the invertebrata (v. Berlepsch, *Die Biene und ihre Zucht*, second edition ; Landois, *Physiologie*) a connexion between food and the development of sex, leave no doubt that, in the case of the human subject also, a certain diet of the mother would not be without influence on the ovum developing within her. Here, however, in the case of the ripening of the ovum, according to my opinion, the result does not depend on the diet

alone, but rather on the process of metabolism in the mother.

How the physiological combustion goes on in the organism, and what changes take place in it, in consequence of the altered diet, until the sugar entirely disappears, is in the case of human beings of the highest importance, and furnishes an index of the consequences.

In individual cases the diet is directed in accordance with the results that show how the food has been assimilated and does not depend upon these alone. In other words, whether the mother eats much meat is a secondary consideration. Whether and how the food taken is completely made use of in the process of combustion—that is a matter of importance for the purpose we have in view.

Any one, who keeps before him the fundamental principles of this theory, will see plainly that it is possible, under certain circumstances, to procure male progeny by means of the influence we have indicated. *The wish to have female progeny is a desire for the gratification of which it is not at present possible to give any directions.*

In connexion with all that I have already said I will here mention that the method which

I employed to procure the ripening of an ovum for male progeny in cases where I had previously found sugar normally present, which served as an indication for the application of my treatment, I attempted to apply also in the case of individuals with whom no trace of sugar was to be found. The method of proceeding, judging by my experiences thus far, should be as follows.

First of all it must be elicited whether any special disease exists, and especially any that indicates anomalies in the metabolism. Of course capacity for generation and the possibility of conception are presupposed.

If the history of the case shows no circumstances that would hinder the application of the method, we inform the patient that she must furnish us with the urine necessary for the occasional examination. It is best to use for this purpose a urine glass marked in grammes and containing two litres, in which the urine of twenty-four hours is to be collected.

It is well at the beginning of the procedure to put a few drops of formaline into the measuring glass, so that the urine may not, in consequence of standing, decompose, and so become unfit for accurate analysis. Of the collected quantity of twenty-four hours, about 200 grammes should be

poured into a small phial, well corked, and used for analysis. In making the analysis it is best to proceed in the following order. First we determine the *reaction* of the urine with litmus paper. In normal urine the reaction is generally acid. Next the *specific gravity* is determined. This is most easily done with Ultzmann's urometer, by means of which the density of the urine can be easily determined. That varies in normal urine generally between 1015 and 1020. In exceptional cases it may sink very low, which often happens after much fluid has been taken. In other cases it rises under pathological circumstances enormously high, as, for example, in diabetes. In the case of a thorough preparation of the organism by the use of a great quantity of concentrated nitrogenous food with a view to influencing sex the specific gravity very often reaches 1030 and more.

After the specific gravity we measure next the *quantity of urine* collected in the twenty-four hours.

We proceed next to determine the normal *urine-sugar*, and for this purpose use a number of the well-known tests—Nylander's, the fermenta-

tion test, and Trommer's test—which have been already described. If these give a positive result, we proceed to a quantitative examination by means of the polariscope. If the quantity of sugar found is very small we exert ourselves to get rid of it by a suitable diet, because otherwise no certain influence over the embryo in the direction of the production of male offspring can be exercised. If, however, we find no sugar by any of the above tests, we seek for it by means of the phenylhydrazin test also described above. A few experiments on the melting point of the phenyl-glycosazon crystals will easily give us certain information. In the analysis we observe particularly whether the positive result of the phenylhydrazin test has originated from the sugar or from the reducing substances. With the polarisation apparatus we determine the quantity of lævo-rotatory substances, *the optical rotation*, in per cents., as these stand in a certain relation to the reducing substances. We make these experiments with urine that has not been decolorised. The former becomes greater as the quantity of the latter increases.

The determination of the reducing substances can be effected by Salkovski's gravimetric method, but I prefer Moritz's volumetric method on account of its simplicity. For the experiment we prepare the following solutions:—1. A solution of sulphate of copper of 80·78 grammes $Cu\ S\ O_4 + 5\ H_2\ O$, in a litre; 2. Solution of caustic soda of 120 grammes $Na\ H\ O$, in a litre; 3. Watery solution of ammonia of 7·1 per cent. $N\ H_3$, specific gravity 0·9722. For conducting the volumetric analysis we place in one of Erlenmayer's flasks, containing about 250 cubic centimetres, about 2 cubic centimetres each of the soda solution and the solution of sulphate of copper, and add 140 cubic centimetres of the ammonia solution. We thus obtain a dark blue fluid, which we now boil. During the boiling we allow the urine to be analysed to flow in from a burette until the fluid becomes colourless. A table given by Moritz in the forty-sixth volume of the *Archiv für klinische Medizin*, shows us in per cents. the quantity of reducing substances contained in the urine we have used.

In conclusion, we investigate the condition of the metabolism by *determining the excreted*

nitrogen. Nitrogen is excreted both by the urine and the fæces. The greater part is found in the urine, whilst, on the contrary, the quantity of nitrogen excreted in the fæces amounts to more [? less] than 1 gramme per day. If, then, we determine the quantity in the urine alone, and add 0·94 gramme as a correction for the nitrogen excreted with the fæces, the resulting error will be unimportant. The best and at present most usual method of determining the nitrogen is that of Kjeldahl. I generally use it in my analyses as one that can be conveniently carried out. For this purpose we place 5 cubic centimetres of filtered urine in a long-necked flask, add about 3 decigrammes of yellow oxide of mercury and 10 cubic centimetres of chemically pure sulphuric acid. We then carefully warm the brownish-black mixture over the flame of a Bunsen burner until it has become colourless. We now allow it to cool. The mixture is now poured into an Erlenmayer flask containing three-quarters of a litre of water, is neutralised with 30 per cent. soda-lye and then 40 cubic centimetres of a 4 per cent. solution of potassium sulphide is added. The whole is next subjected to distillation. Decinormal sulphuric acid contained in the receiver takes up the ammonia which

distils over. The acid still remaining free after the completion of the distillation is titrated with decinormal caustic soda. As 1 cubic centimetre of decinormal sulphuric acid corresponds to 0·0014 gramme of nitrogen, we can easily reckon the quantity excreted daily. We know how much nitrogen is contained in 5 cubic centimetres of urine, and can easily find to how much the daily quantity amounts by multiplying by it and dividing by 5.

The nitrogen found in the urine can be expressed as albumen by multiplying it by 6·25 (Neumeister), at the same time making a correction for the nitrogen in the fæces as described above.

This is all that there is to say about the analysis of the urine, which is of so much importance for our experiments. In order to show the practical application, I will add the following analyses, as actually made in exercising an influence over sex to obtain male offspring.

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1. Case of a woman twenty-three years old, who, before anything was done to influence the sex of her offspring, had been married five

years, and had given birth to two girls. The urine was collected from eight in the morning until the same hour of the next day in a measuring-glass. The quantity in twenty-four hours was 1650 cubic centimetres. Analysis gave the following results :—

ANALYSIS.

Reaction : Acid.
Specific gravity : 1017.
Quantity in 24 hours : 1650.
Colour : Light yellow, fairly pale.
Sugar : None perceptible with Trommer's test, the fermentation test, and Nylander's test.
Phenylhydrazin test : Negative.
Optical rotation : Very slight, not determinable.
Reducing substances : 0·135 per cent.
Nitrogen : 12·76. (Correction : 0·94.)
Nitrogen as albumen : 79·75.

I recommended that more meat should be taken, and that sugar and other forms of carbohydrate should be avoided. After the lapse of eight days, I again procured urine for examination. Analysis gave the following results :—

ANALYSIS.

Reaction: Acid.
Specific gravity: 1018.
Quantity in 24 hours: 1050.
Colour: Somewhat darker than on 17, 1.
Sugar: None perceptible with Trommer's test, the fermentation test, and Nylander's test.
Phenylhydrazin test: Negative.
Optical rotation: Not determinable.
Reducing substances: 0·15 per cent.
Nitrogen: 13·5. (Correction: 0·94.)
Nitrogen as albumen: 84·37.

The result was that the reducing substances and the nitrogen (expressed as albumen) had increased. The diet of this woman was constantly altered in the direction of increasing the amount of albumen, until, after the lapse of about three weeks, the following results were obtained:—

ANALYSIS.

Reaction: Acid.
Specific gravity: 1030.
Quantity in 24 hours: 1000.
Colour: Dark, brownish-yellow.

Sugar: Cannot be determined by Trommer's test, the fermentation test, and Nylander's tests.

Phenylhydrazin test: Positive; the glycosazon-crystals have melting-point 110° Cent., therefore do not result from sugar.

Optical rotation: 0·2 per cent. lævo-rotatory.

Reducing substances: 0·32 per cent.

Nitrogen: 21·9 gramme (Correction 1 gramme).

Nitrogen as albumen: 136·8 grammes.

The woman was kept in this condition four weeks. In the meantime menstruation took place. It lasted four days, during which time no change appeared in the analysis. An analysis was made every week, another menstruation occurred lasting four days, and impregnation took place six days later. After this the menses ceased. As I mentioned above, the sex of the embryo is already determined in the third month of pregnancy, for which reason I kept the patient under dietary influence up to that time. In the interim I made ten analyses at short intervals, the average results of which I shall now give.

AVERAGE OF TEN ANALYSES.

Reaction: Acid.

Specific gravity: 1028–1032.

Quantity in 24 hours: 750 cubic centimetres, to 1200.

Colour: Golden yellow, always dark.

Sugar: None could ever be detected.

Phenylhydrazin test: Positive (owing to the presence of glycuronic acid compounds; melting-point of crystals 105° Centigrade to 120°).

Optical rotation: 0·2–0·3 per cent. lævo-rotatory.

Reducing substances: 0·29–0·35 per cent.

Nitrogen: 17·9 grammes to 22 grammes (Correction 1 gramme).

Nitrogen as albumen: 111·8–137·5 grammes.

When after 5 analyses the nitrogen expressed as albumen had reached its highest point, it fell suddenly. Some immediate experiments proved that it was necessary to give more carbo-hydrates and less albuminous food, in order to re-establish the previous relations.

The woman was subsequently allowed to follow whatever course she preferred, and bore a fine boy at full term.

The task still remains of examining many facts and theories already known which may apparently be contradictory to our teaching.

And here should be first of all taken into consideration the experiments in diet made by various stock-breeders (Bellingers, Wilkens, &c.) In them, however, the results of the analysis of the products of excretion are not given, and in particular there is no information respecting the combustible and useable sugar evacuated from the organism, or any other substances from the organism which might have been of importance for the evaluation of the food. It is possible that in experiments with diet, without reference to the excretion of sugar, the results may be sometimes in favour of the male sex and sometimes in favour of the female sex, upon which latter no active influence is exercised. Herr U. P., a nobleman resident in a country district of the Russian Baltic provinces, informed me by letter that in his herds the greater number of calves are born in February. The February calves are principally male. The cause in this case may be as follows :—Conception takes place in the May of the previous year. After having been kept some six months in the cow-houses the beasts are turned into the spring meadows, and are impregnated at a period when

metabolism is active in consequence of their altered mode of life. All the cows are in heat. The notable result obtained in the ensuing February may be explained as the consequence of the better physiological combustion of the food.

According to statistics more boys than girls are born in the years with a poor harvest. Bad harvest years are those which favour a flesh diet, as the food-stuffs from the vegetable kingdom do not suffice for the cattle, nor for the people either; in consequence of which the cattle are killed, and more flesh enters into the diet of the women who are fructified. If people in general had the normal aptness for procreation in such famine years, the flesh-diet might turn the scale in favour of the male sex; it being presupposed that the other conditions were fulfilled.

If Thury's law be considered, Thury also held the ripeness of the ovum to be of importance for male or female ova. The ova were regarded by this author as being more or less ripe, or as male and female, according to the time whether it happened to be at the beginning or at the end of the rutting. To me, however, the ripeness seems to depend upon the process of physiological combustion in the organism of the mother. According to Thury no attention need

be paid by us to the ripeness for fructification, as this ripeness is attained independently of our interference. But, on the other hand, our influence has the effect of producing a male ovum out of the ovule ready to be fructified.

If the dieting of a woman in the way we recommend is practicable and of definite effect upon the development of the future sex, we arrive at a conclusion which may be summed up as follows :—If a woman be dieted according to our method, she can reach a stage in which she becomes sexually superior to the man, and her offspring will then be male, in accordance with the law of the cross-heredity of sex.

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